AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

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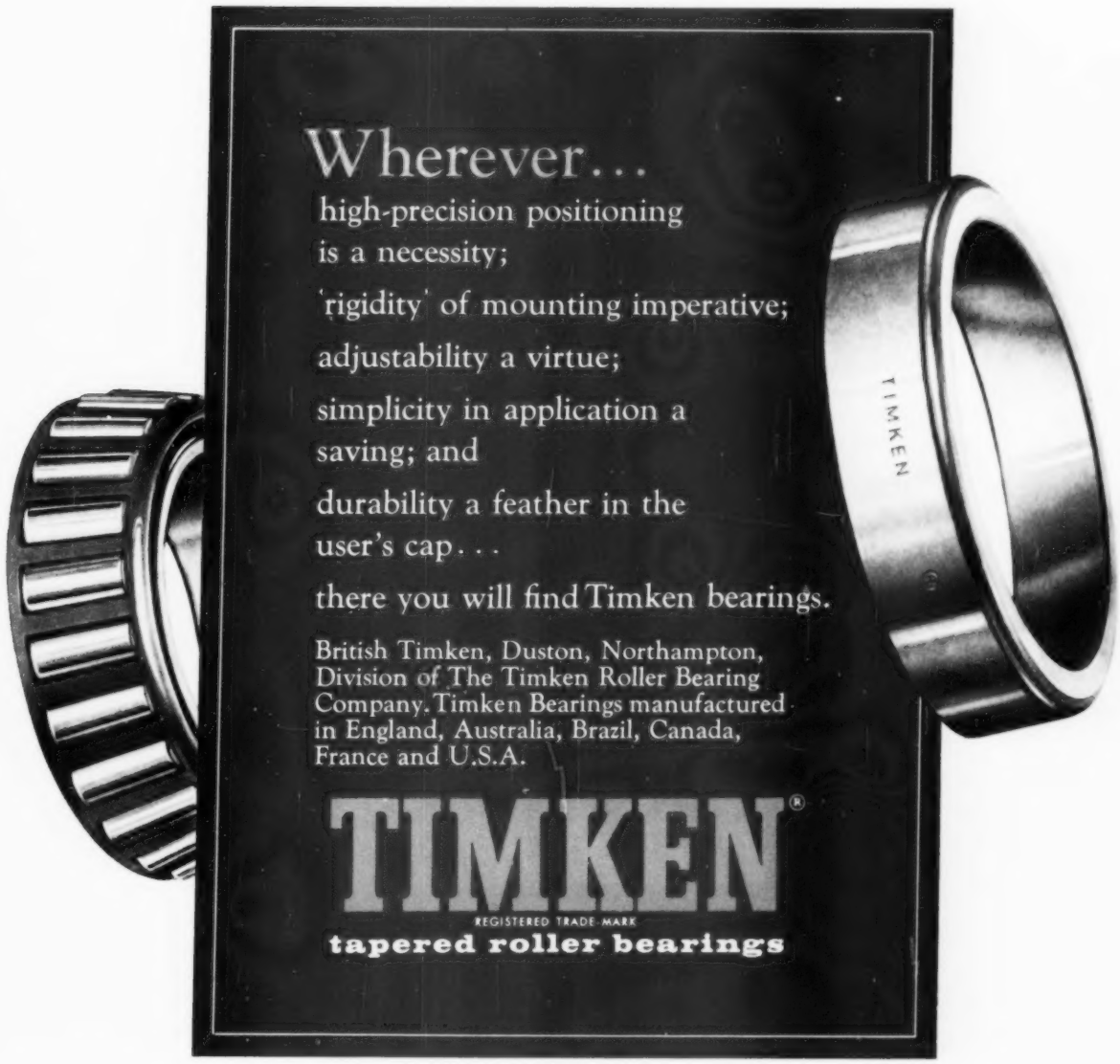
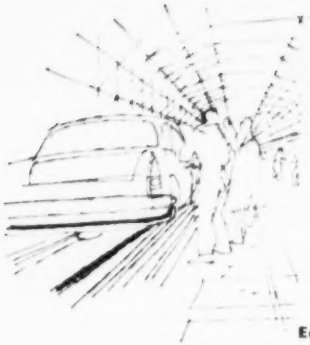
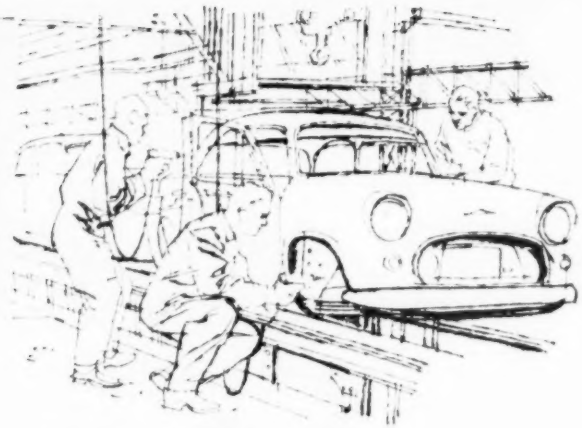
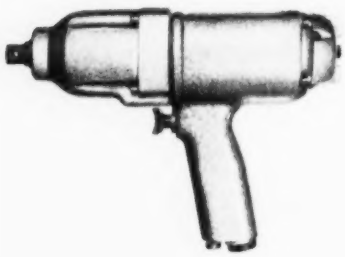


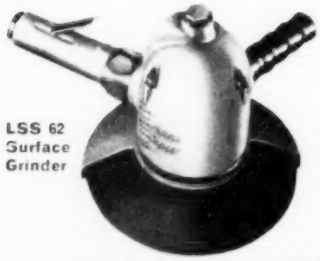


Ecco 40 Spray Gun



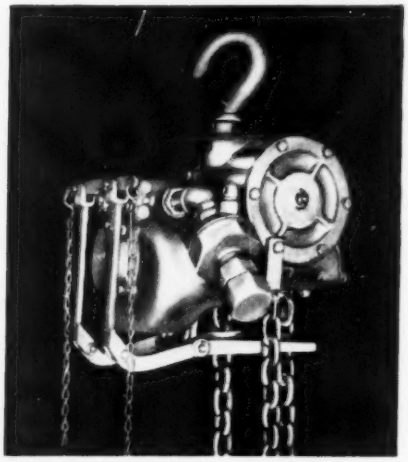


LMS 25 Impact Wrench



LSS 62 Surface Grinder

MT505 Hoist



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Here's AIR POWER for production line efficiency

Atlas Copco's range of equipment for the motor industry includes air-powered tools anatomically designed and balanced to speed up production and reduce operator fatigue. With their excellent power weight ratios, these tools make an important contribution towards higher productivity.

Wherever there are nuts to be tightened, screws to be driven, loads to be lifted or surfaces to be smoothed and painted, Atlas Copco can supply reliable, high-performance, air-powered equipment, together with stationary compressors for every requirement from operating a spray gun, to supplying the complete air needs of a large factory.

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Atlas Copco is the world's largest organisation specialising solely in compressed air equipment. Wherever you are, the international Atlas Copco group offers expert advice on the selection of equipment and provides a complete after-sales service.

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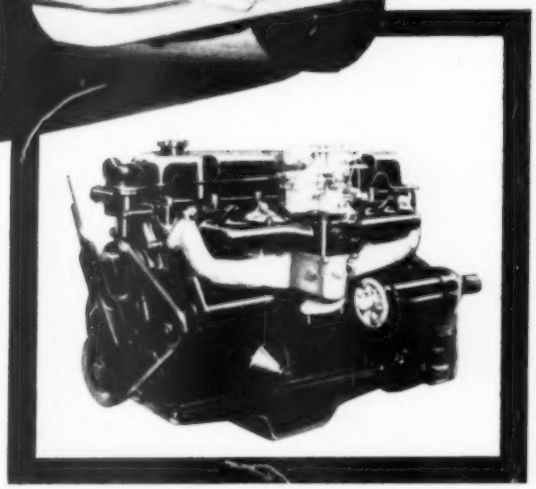
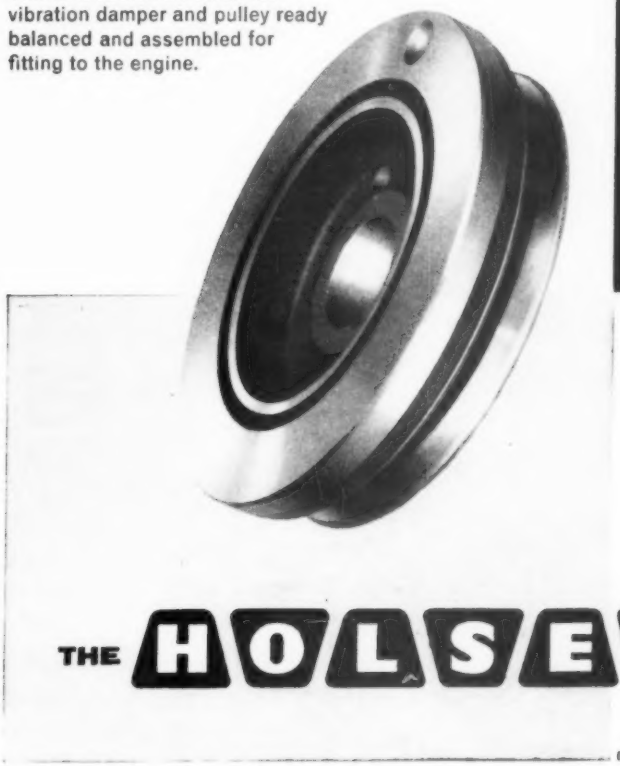
The new 2.6 litre 6-cylinder engine which powers the 1961 Vauxhall Velox and Cresta models is fitted with a Holset Non-bonded Crankshaft Damper. This is a combined torsional vibration damper and pulley ready balanced and assembled for fitting to the engine.





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B 521

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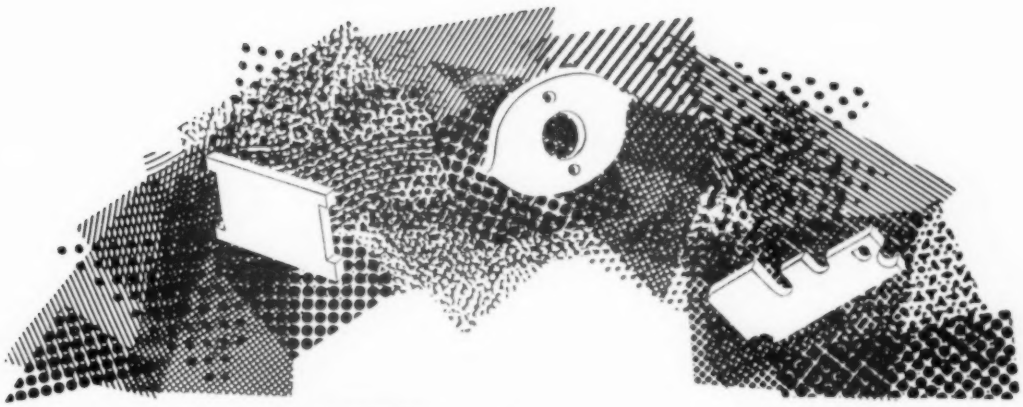

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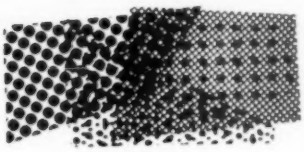

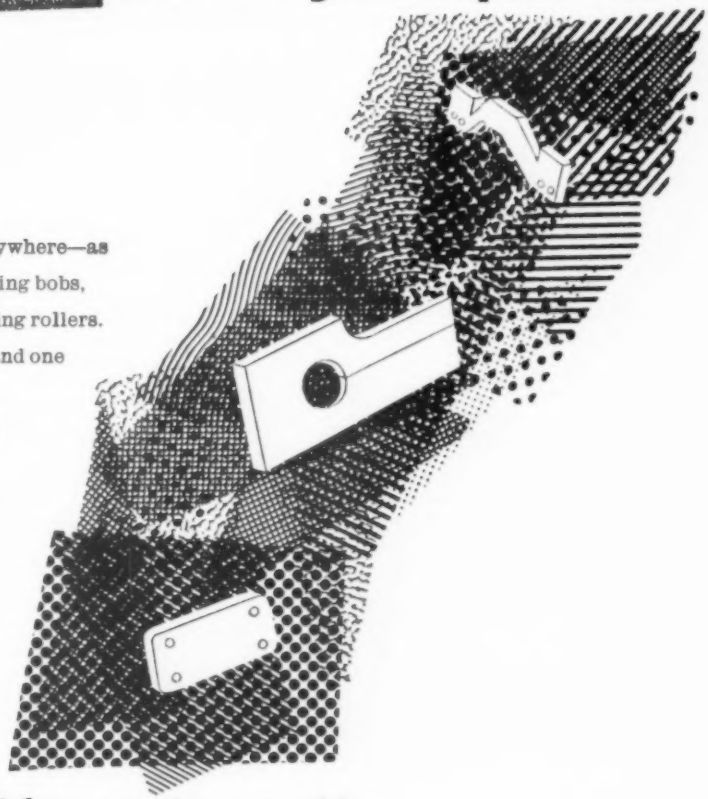

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BURY FELT

64

Also manufacturers of
'FOAMBURY' Plastic Foam products

This is Tecalemit isn't it?

TECALEMIT—LUBRICATION, of course. You see the Tecalemit target and arrow sign and take the car in for lubrication service. Grease pumps, pipes, lifts, oil dispensers, air compressors—everything's Tecalemit, right down to the grease nipples. So it's simple: Tecalemit stands for Lubrication.

But Tecalemit stands for filtration

In spite of high compressions, greater loadings and higher speeds, modern car engine bearings can tolerate almost anything—anything except foreign bodies in their oil. Thus the Tec-element: an oil filter element of astonishing efficiency. Most leading British engine manufacturers fit Tecalemit oil filters and so recommend Tec-elements as replacements. Sound advice!

But Tecalemit make precision nylon piping too

Nylon piping for automotive uses was once merely a Good Idea. If only you could use it, it would be cheap, vibration resistant, strong, supple, chemically inert and so on. But how could it be produced to precision limits? Tecalemit found the answer—a resounding and exclusive technical triumph. Nowadays such great names as Austin, Aston-Martin, Ford, Jaguar and Rover use a great deal of Tecalemit extruded nylon piping for fuel lines and vent pipes.

But Tecalemit are famous for oil firing

Oil firing: it takes you out of the automotive field and into the brickworks and kilns. Much tidier brickworks, of course: no heaps of coal and slag. Just pipe runs, control panels, high efficiency and low cost. Oil firing is becoming a major industry in itself—and Tecalemit one of its most prominent names.

But Tecalemit make a thousand other things

Grease guns, power pumps, hose reels, lifts, sprayers, washing units . . . automatic and multiple lubricating systems for machinery and vehicle chassis . . . air cleaners, breathers and ribbon elements (finest air filtration at lowest cost) . . . in fact, an amazing number of things that help keep industrial and automotive machinery washed, pressured, connected, controlled, raised, lowered, filtered.

Oh yes—and lubricated. For of course Tecalemit stands for lubrication.

TECALEMIT **the Authority on Lubrication**

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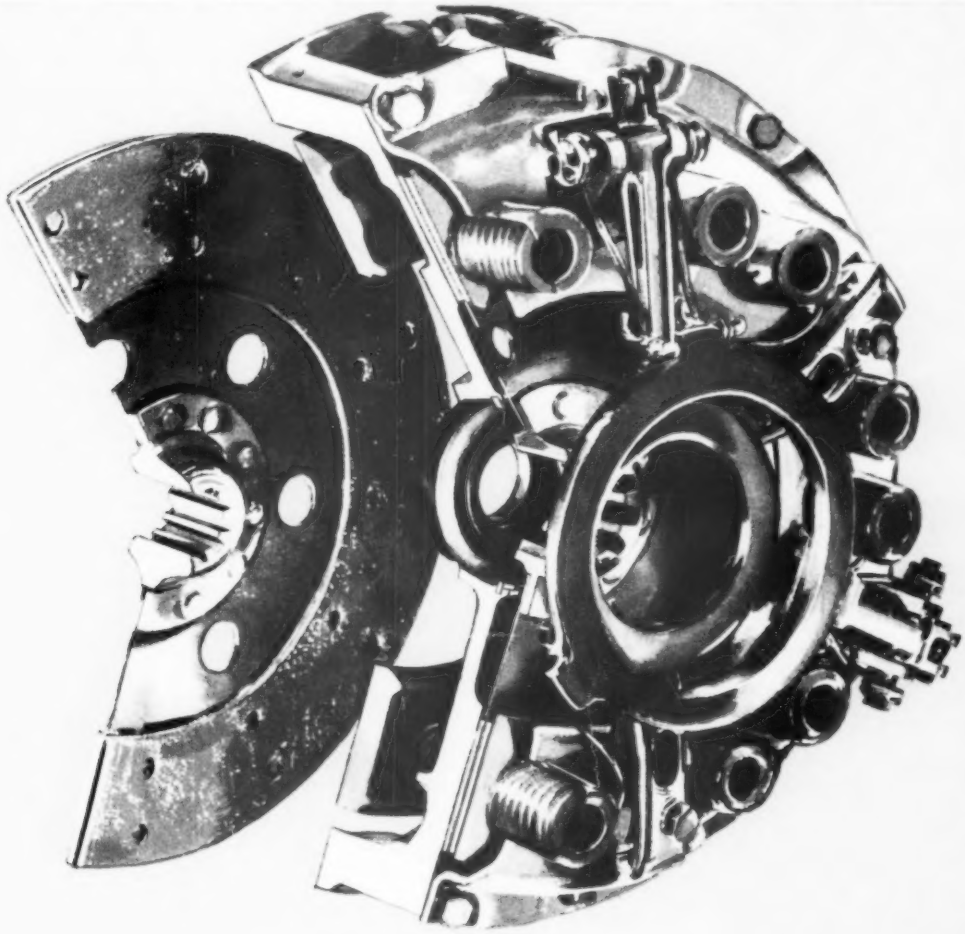
FOR AGRICULTURAL TRACTORS



The integral clutch and power take-off for tractors comprises two clutches mounted in tandem. The clutch nearest the flywheel transmits the drive to the rear wheels through the usual splined clutch shaft; the other clutch provides a power take-off for driving a combine, baler, mower or other machine and transmits its power through a hollow splined shaft.

In most cases a separate engine for driving implements is rendered unnecessary.

The two clutches have independent throw-out forks with ball-thrust bearings.

In addition there is a wide range of Rockford over-centre clutches and power take-offs, and an extensive range of Borg & Beck clutches covering all requirements. Ask our representative to call and discuss your problems.

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FOR TRACTORS & TRAILERS

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They form a light, powerful, inexpensive braking system giving controlled safety with maximum economy and negligible maintenance. For actuation manually, or remotely by vacuum and air systems.

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Lockheed Avery

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The 'Hydralinc' coupling shown enables the user to make the most of his hydraulic implements. Hydraulic lines can be quickly connected and disconnected without loss of fluid or inclusion of air.

There is no need to prime fluid systems fitted with this coupling. For pressures up to 3,000 p.s.i.

Lockheed-Avery hoses are made to a very high specification in order to provide consistent durability in agricultural usage. The end-fittings are re-usable when the hose is renewed.

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FOR AGRICULTURAL TRACTORS

The Purolator system of filtration will prevent rapid deterioration of tractor engines working under arduous conditions of dust and grit in the field.

AIR FILTERS

The Purolator Dry Type filter is capable of arresting particles of foreign matter small enough to be measured in microns. These filters are particularly suitable for use on combine harvesters where engines work under conditions of excessive dust.

PUROLATOR

Regd. Trade Marks: Purolator, 'Micronic'

MICRONIC FILTERS

OIL FILTERS

Purolator Micronic full flow filters are designed to handle all the oil supplied to the engine bearings under normal operating conditions. A relief valve is incorporated to ensure a continuous supply of oil should the element have been allowed to become choked through neglect. Designed for mounting directly on to a machined facing on the engine crankcase, these models dispense with external piping.

FUEL FILTERS

These diesel engine fuel filters are designed to give final protection immediately prior to the injection pump. The filter bowl has ample capacity for water and sediment which may be drained off periodically.

Our engineers will be pleased to discuss your filtration problems on request.

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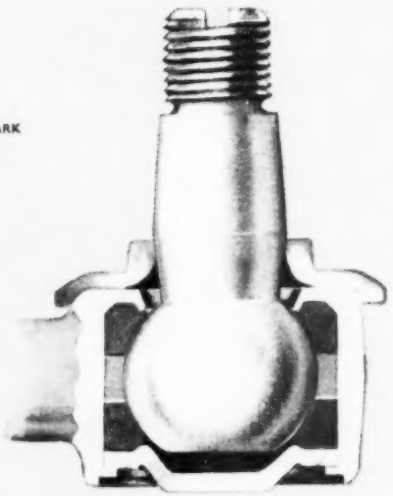
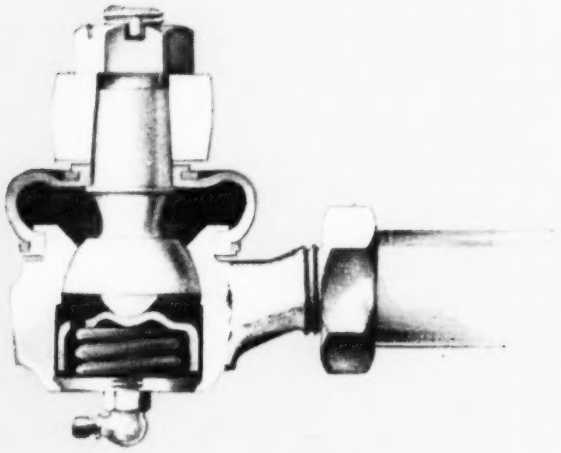
Autolube REGD. TRADE MARK

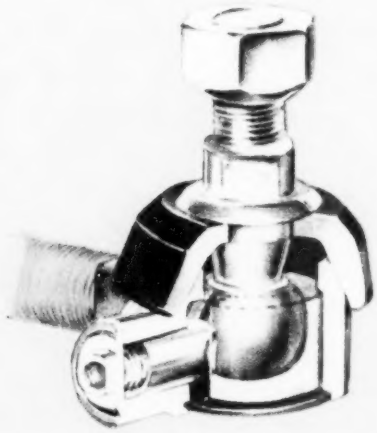
SELF-LUBRICATING JOINTS

Autolube joints give 'built-in' automatic lubrication, eliminating servicing at inaccessible points. Two resilient fabric bushings, impregnated with a patented 'dry' lubricant, carry the normal steering loads, and provide freedom from backlash. Between the resilient bushings is a Nylon ring which protects the fabric from shock and overloads, and enables it to retain the lubricant, which is essential to the prolonged life of the joint.





Thompson steering joints have been specially designed to withstand the continual hard wear imposed by the operation of tractors over rough ground, without the need for constant maintenance and adjustment.



This special purpose joint was developed expressly for use on a mowing machine, and is self-adjusting. We are prepared to develop joints, for use on original equipment, to suit any requirements of the agricultural industry and our lengthy experience is at your service.

May we send our catalogue of standard joints?

Thompson

Regd. Trade Mark

SELF-ADJUSTING BALL-JOINTS

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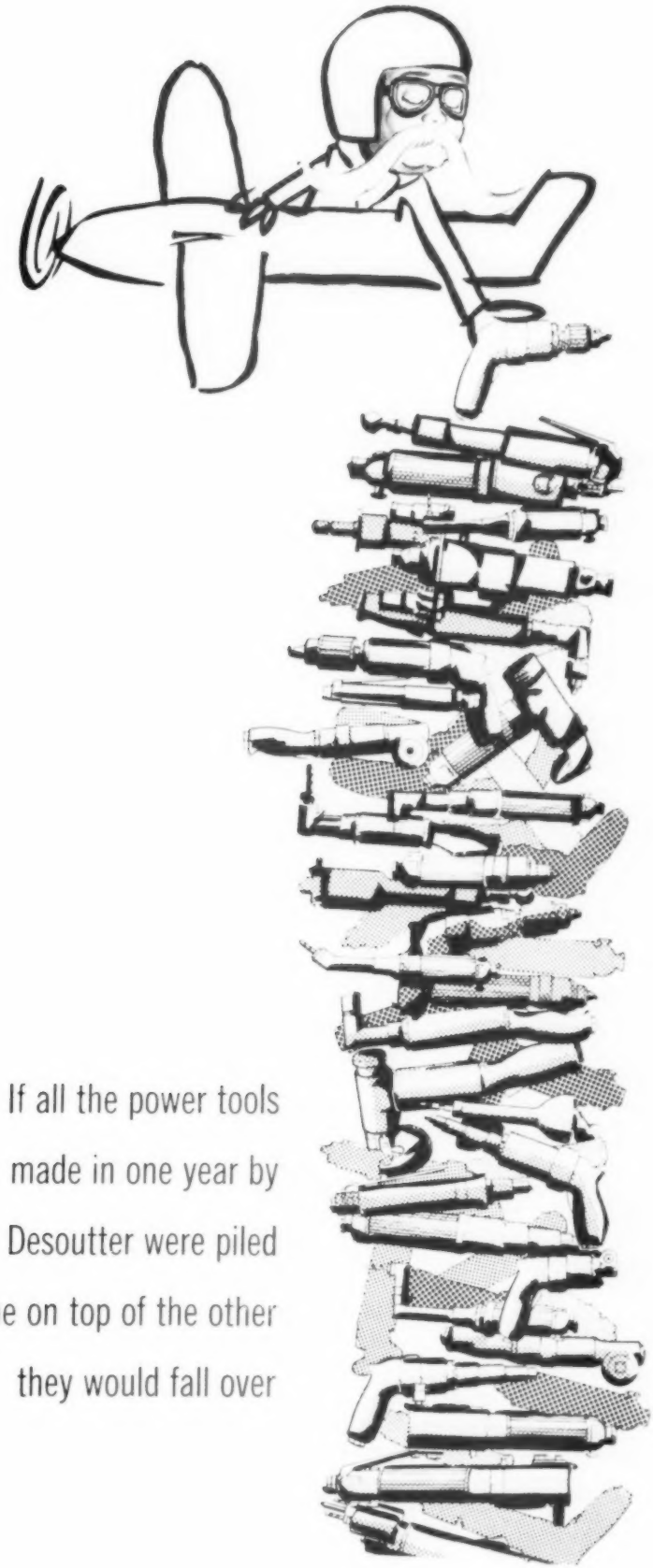


If all the power tools
made in one year by
Desoutter were piled
one on top of the other
they would fall over

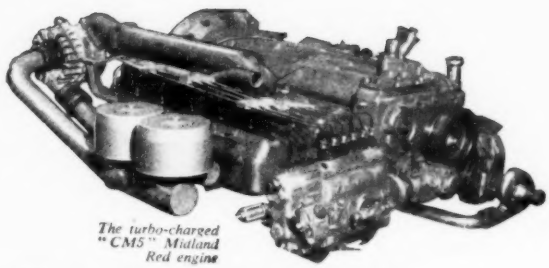
Dualloys

MAIN and BIG END BEARINGS

can immediate solution of your bearing problems

DUALLOYS BEARINGS FOR THE M1.
The Engines of the famous Midland Red Coaches, which average 60 mph (top speed 85 mph) on the M1, are fitted *exclusively* with Dualloys Main and Big End Bearings, as are *all* Midland Red Engines now being built.

FOR ALL INTERNAL COMBUSTION APPLICATIONS to every specification. Dualloys thin wall bearings can now be supplied as original equipment. Dualloys thick wall white metal lined, and copper-lead and lead-bronze lined bearings are already specified as original equipment by many leading firms* at home and abroad for petrol and diesel engined public service and road transport vehicles. Our unique process prevents all lead segregation and copper hardening.



The turbo-charged "CM5" Midland Red engine

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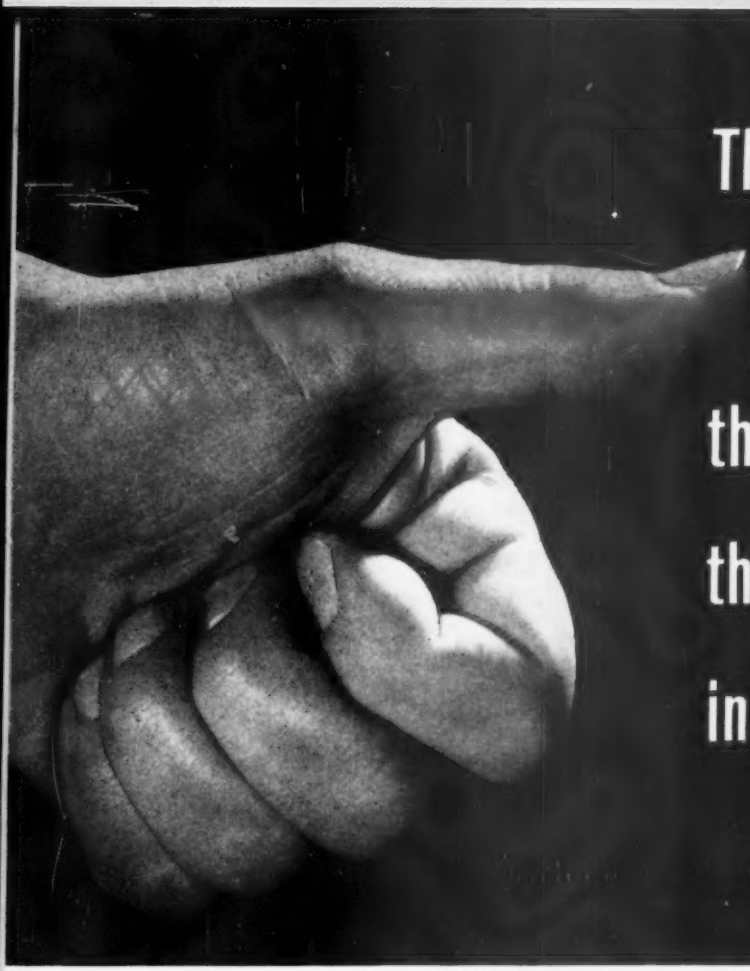

This is the thumb that starts the machine that cuts gears faster than any other machine in the world

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in a wide range of standard sizes

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Polyslip 1M Dry Bearings are designed for high duty without lubrication of any sort. They are intended for those applications where other lubricants are undesirable or unsuitable.

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Bearings made from sintered bronze, impregnated with P.T.F.E. (Polytetrafluoroethylene) and additives at the working surface.

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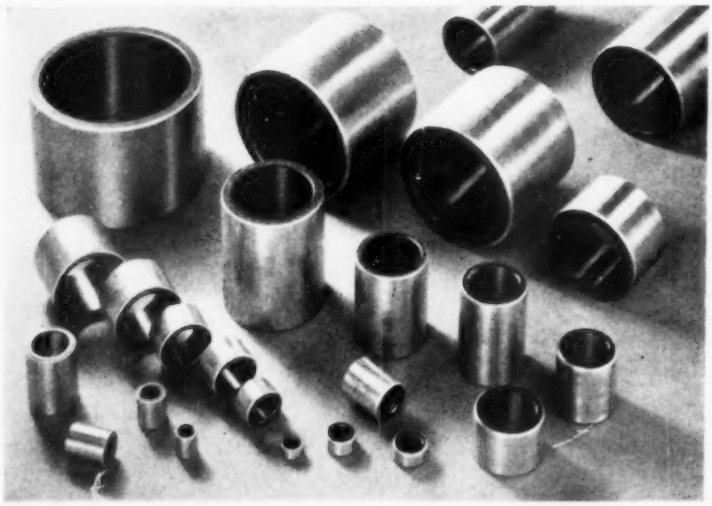
What Sizes?

From 0·1″ to 3″ bore. Standard sizes facilitate quicker delivery.



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Where oil and grease lubricants are unacceptable.

Where shafts are required to run in liquids such as water, petrol, solvents. Where dust is a problem · Where oil and grease can cause contamination. Where maintenance may be at a minimum · Where temperatures are abnormal. Where 'static' is a problem · Where 'slip-stick' motion must be avoided.

Our Technical Department will be glad to discuss the suitability of Polyslip 1M Dry Bearings to your applications.

Write for a designer's brochure giving properties, performance data, and dimensions.

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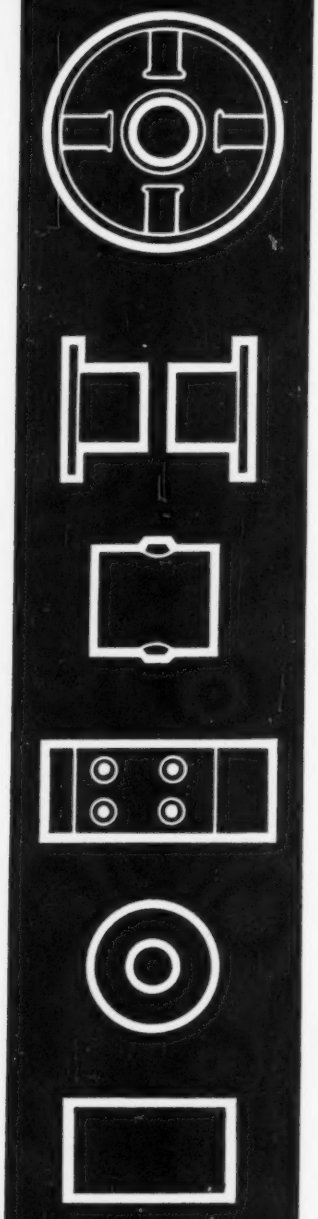

The Nylastic bearing is now firmly established in the Automotive world as the ideal bush for many swivel arm and lever applications. Nylastic is also used for track-rod ends, diesel fuel pump coupling discs, chain reaction pads, cable support clips, thrust washers etc., and is used with combinations of rubber and metal for steering column bearings, anti-vibration clips, earthing clips etc.

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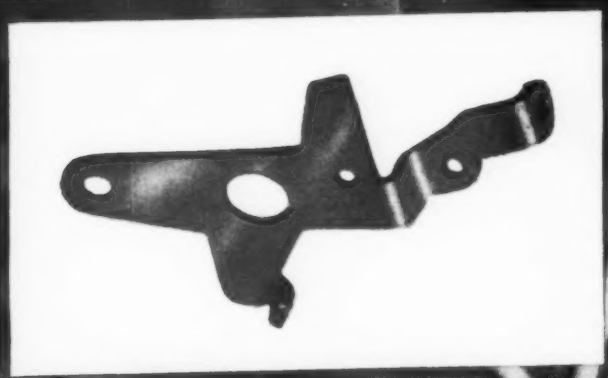

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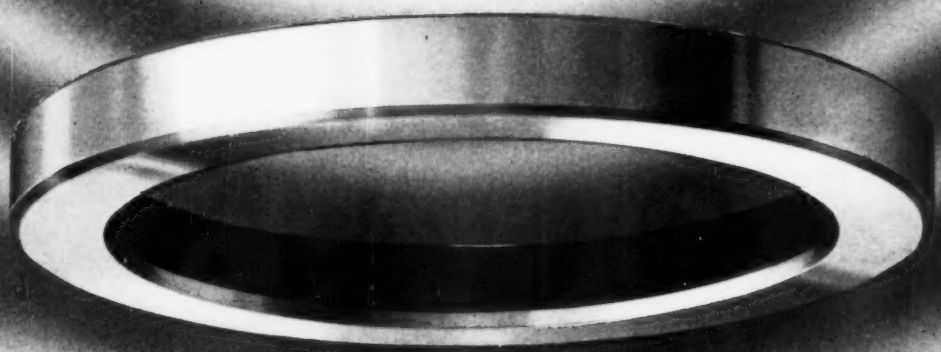

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HIGH SPEEDS COUPLED WITH
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a C.B.A. type seal with contact ring

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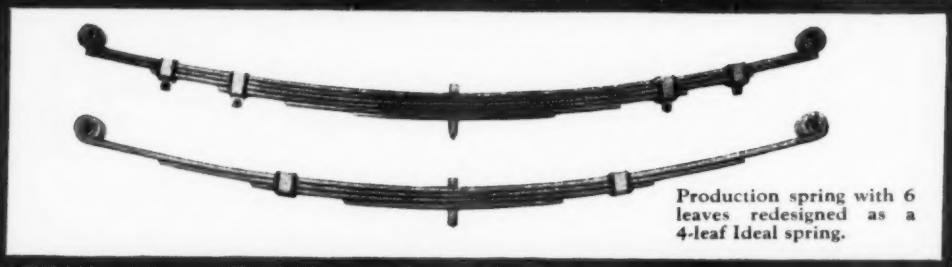
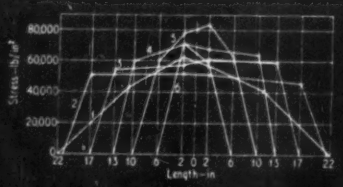
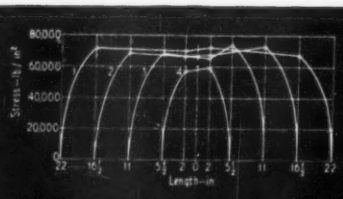
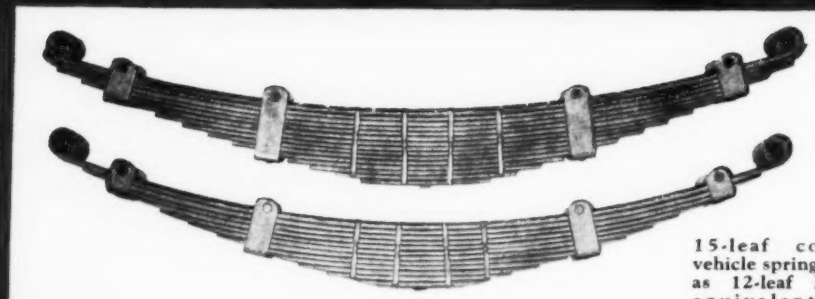


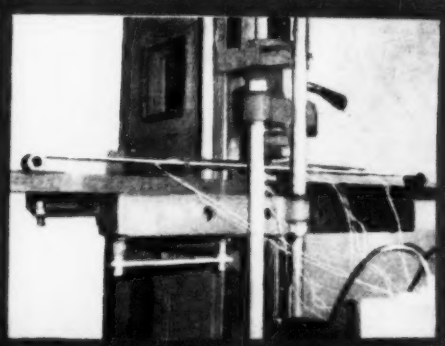
Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.







15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



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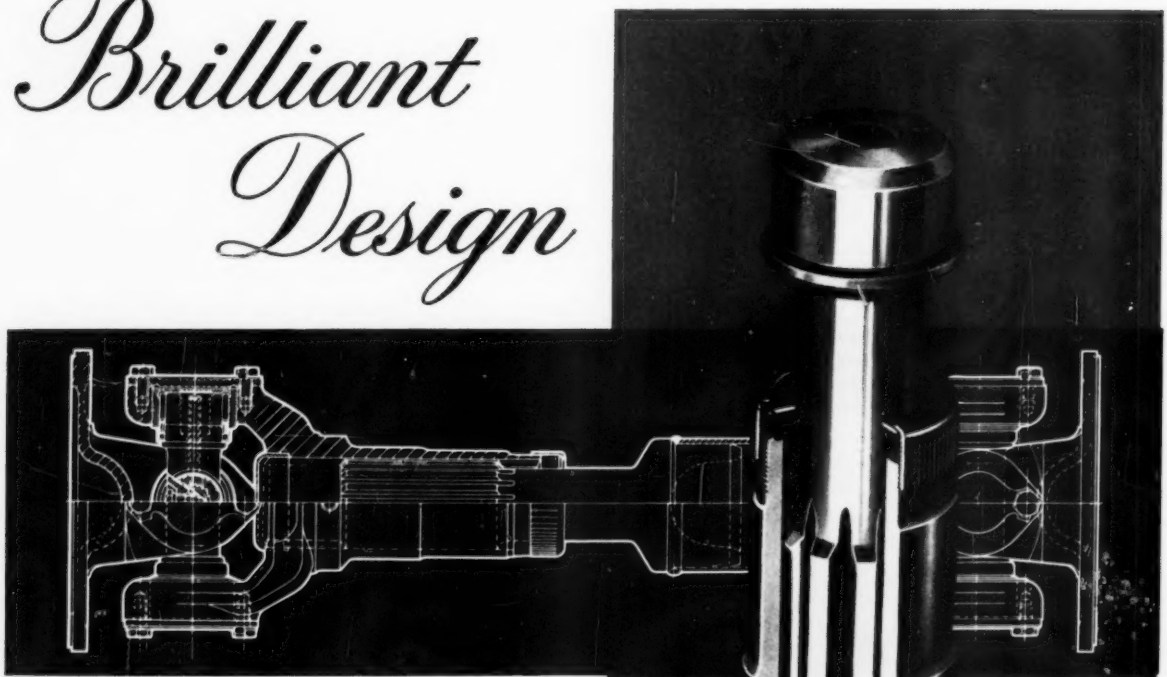

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Shell Rotella Multigrade Oils

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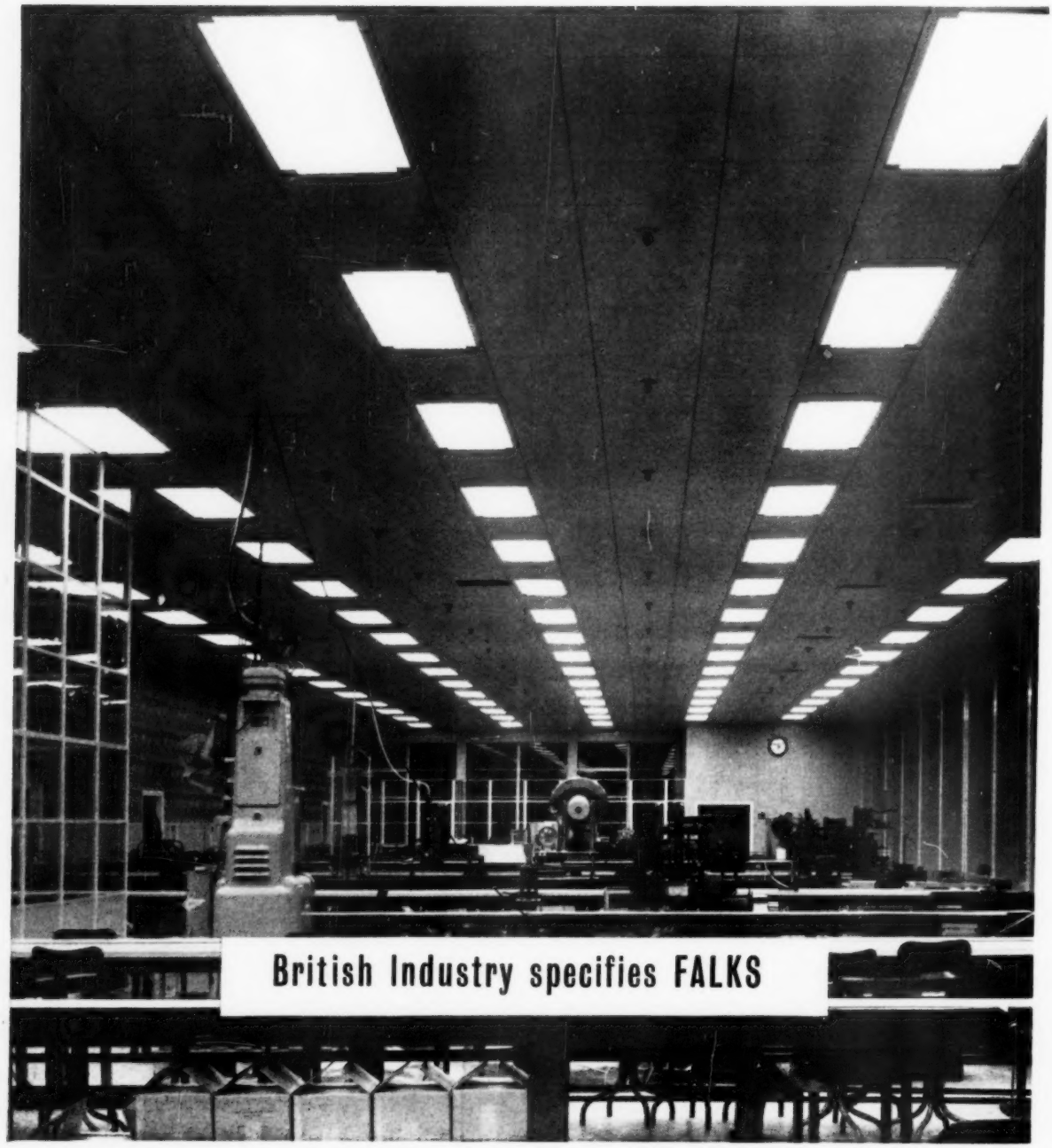

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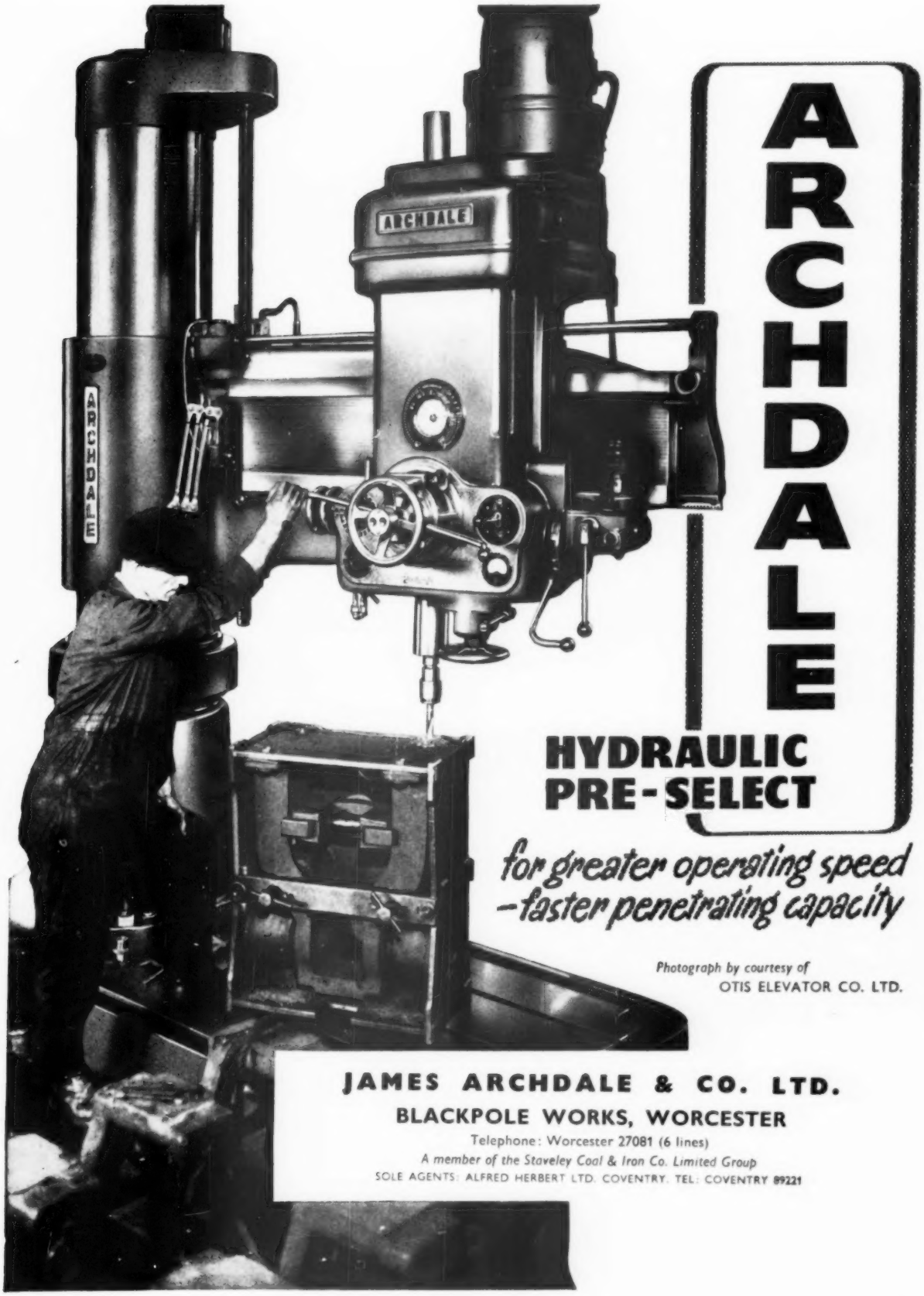

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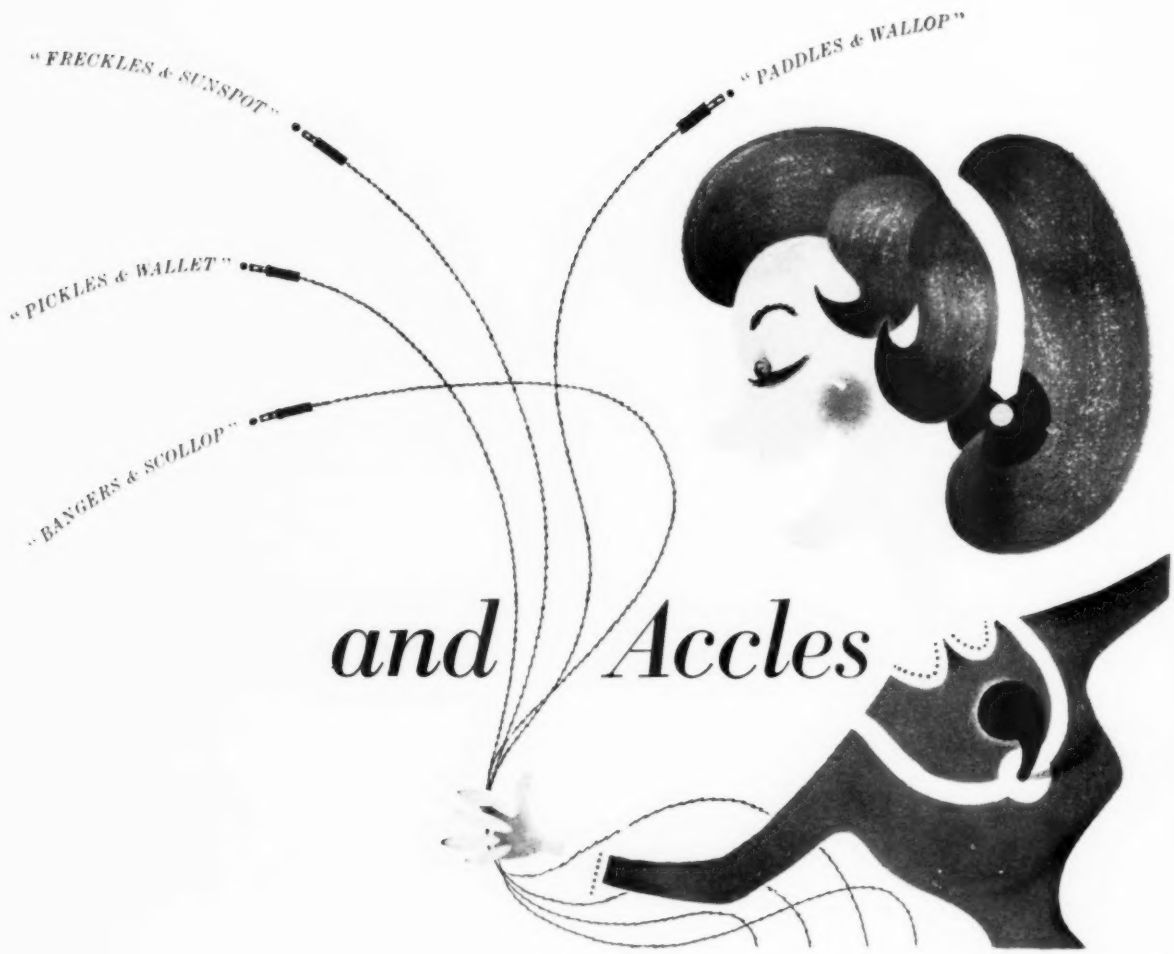

TO CHANGE a lump of stainless steel into a tiny tube ·011 ·0115″ o.d x ·005 ·007″ i.d, used for the manufacture of automatic knitting needles in the textile industry, is only one of the many miracles that Accles & Pollock create for science and industry at their works at Oldbury, Birmingham.

Behind this brilliant engineering know-how that will design and produce tubes of any size, any complexity, is the direction and impetus of a dynamic management that secures long-term advantages as well as immediate gain when making decisions. That's why Accles and Pollock choose *coal* to keep their boilerhouse at its efficiency peak. Their experience has proved that coal, mechanically stoked, *gives the maximum heat for the lowest cost:* and they know that there is no shortage of coal—the home produced fuel.

When the question of fuel for your factory is on the agenda, remember Accles & Pollock. Their choice is coal for a progressive and prosperous industry. Even if you get the name wrong, you get the decision right when you follow their example.

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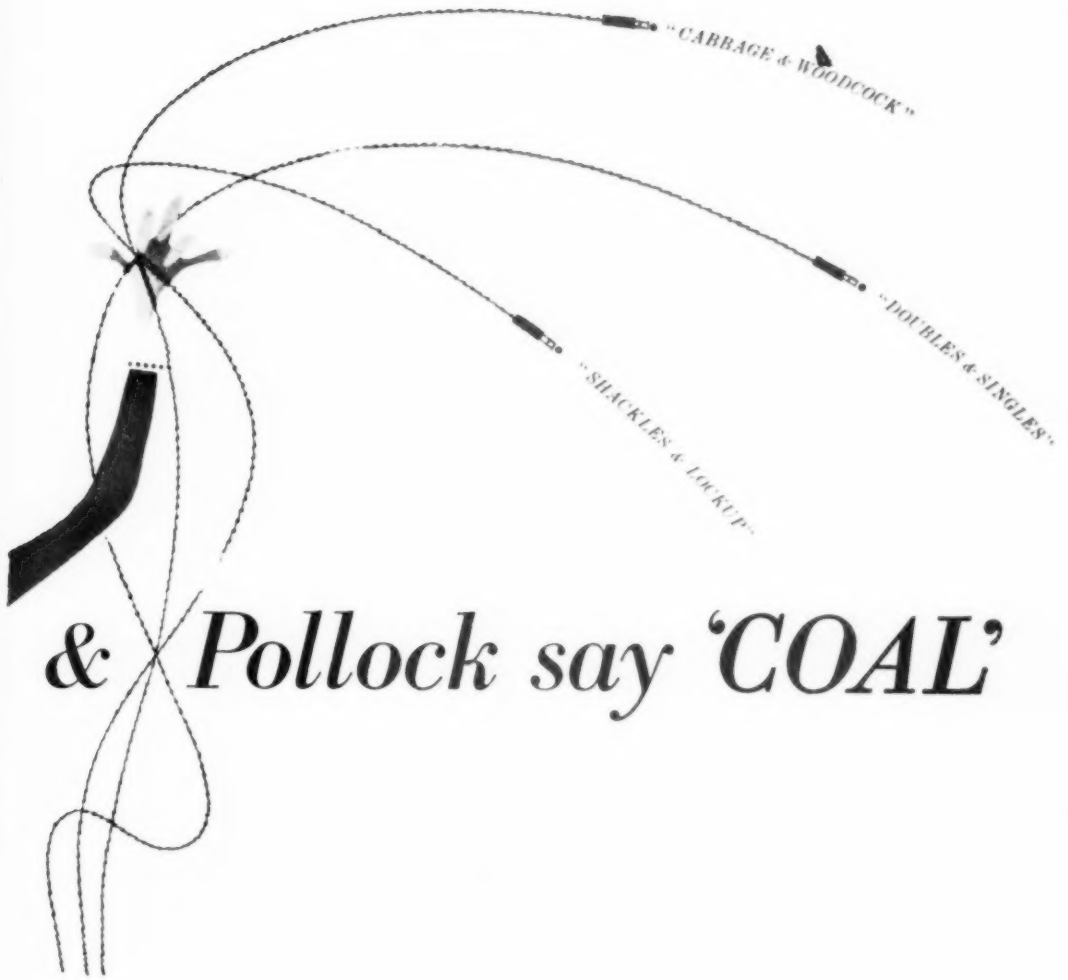
ISSUED BY THE NATIONAL COAL BOARD



& Pollock say 'COAL'

Mr. W. E. Powell, fuel engineer, comments: "Our boilers were designed, primarily, for burning the slack grading of solid fuel. Following experiments into ultimate economies, however, it was decided to change to the better fuel of the 'bean' grading. Under test, it was found that solid fuel gave us excellent combustion conditions, at a challenging price per thousand pounds of steam. By making use of modern mechanical means of firing we are able to maintain strict control of operation practice.

The boilers are of the non-flue type, and when fitted with grit arresters they satisfy all local and national regulations governing grit and smoke densities.

Most fuels can be controlled to give economical generation on the level obtained by solid fuel, but the use of coal does not entail the provision of ancillary equipment so necessary to the use of other heating mediums.

The present boilers have been in existence some ten to twelve years, and during that period we have experimented with all available means towards obtaining the best from our equipment. All our tests bring us back to the use of the 'bean' size coal. Given this heating medium, the operators have no difficulty in maintaining the efficiency level nominated by us. That is why we shall continue to use coal at Accles and Pollock."

And here are some key facts and figures about the Accles & Pollock boilerhouse at Oldbury

Number of boilers	5 water tube
Method of firing	Chain grate stoker
Steam pressure	120 lbs. per sq. inch
Steam temperature	340°F.
Continuous max. rating	72,000 lb. per hour
Annual fuel consumption	20,000 tons of coal

ON COAL

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Electric Motors & Controls-2

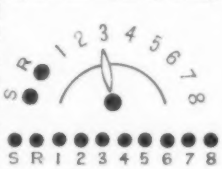
Control equipment must enable the motor to be operated effectively, to obtain maximum productive efficiency of a given machine. An outstanding advantage of individual electric drives is the flexibility of control available. Control equipment may be manual, semi-automatic or fully automatic, and includes gear for the following operations:

(a) Starting
(b) Speed Control (this subject will be dealt with in Data Sheet No. 16)
(c) Reversing
(d) Stopping
(e) Switching off automatically if operating conditions become abnormal
(f) Isolation of motor and control equipment from the supply.

Every application of power has its own particular control requirements—and they are legion. Below are featured four uses of electric motors and their controls; they are given only as examples and represent but a small fraction of the whole picture.

Turret-lathe Control

Various speeds are required for different tools, and it is possible to arrange, for instance, for a four-speed headstock, forward and reverse, incorporating a power-operated pre-selector speed change. By using a two-speed double-wound motor, eight speeds forward or reverse are obtainable. A dial on the headstock is set to the required speed and when a knob in the centre of the dial is pressed, the power-operated mechanism changes the speed instantly.

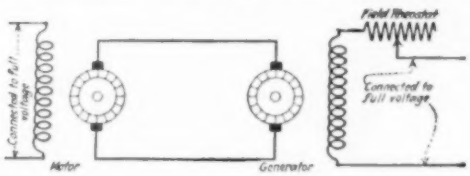


Crane Control

This is a form of control which must be flexible yet completely foolproof. It is, for instance, possible to arrange for motor switching to be performed by contactors in response to movement of the crane driver's master controller which has a number of notches, each of which is associated with a particular set of contactors for acceleration, speed control, reversing and braking. If the controller is moved quickly from the 'off' position to the 'last point lowering', the rate of acceleration is limited automatically by the relays. These also govern the retardation in order to prevent a heavy descending load being stopped too suddenly. This is just one of the ways in which electric control mitigates the hazards of crane operation.

Planing-machine Control

Another example of motor control for machine tools is that for planing machines. For general workshop machining, the Ward-Leonard controlled motor, with a speed range of 10 to 1, gives a rapid and smooth reversal of the table travel and is ideally suited for short-stroke work. Two arrangements of Ward-Leonard control are available, the 3-machine set with generator, exciter and driving motor, and a specially designed 4-machine set with an additional auxiliary exciter. With the 3-machine set the control



equipment can include magnetic time relays which automatically adjust a regulator to strengthen the motor field at the instant of reversal and therefore greatly increase the accelerating torque. The auxiliary exciter of the 4-machine set automatically provides 'field forcing' on the generator; in other words, the power input to the motor is increased to give more accelerating torque at the instant of reversal.

Automatic Control

The control equipments described incorporate automatic features which help considerably towards obtaining safe and efficient operation of the driven machine, but much still depends on the human element. Braking equipment, for instance, cannot always become effective until an operative has taken some action. In an emergency this physiological time lag which delays the initial action will also delay the final effect. Fortunately it is often practicable to employ devices, which will be described in other Data Sheets, to 'observe' any abnormal condition and immediately and automatically to initiate the braking system.

Particular attention should be paid to the positioning of controls. When a machine, or group of machines, requires a large number of push buttons and, in some cases, instruments, etc., the controls can be grouped on a desk with a mimic diagram, located in a position where the operator has full view of the work.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. TEMple Bar 9434.

They can offer you excellent reference books on electricity and productivity (8/6, or 9/- post free)—'Electric Motors and Controls' is an example.

E.D.A. also have available on free loan within the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

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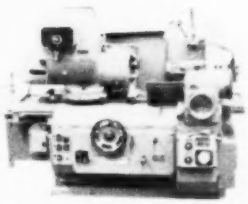

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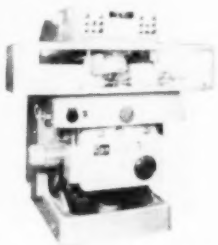

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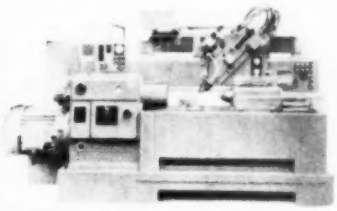

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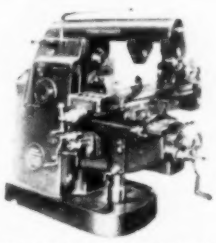

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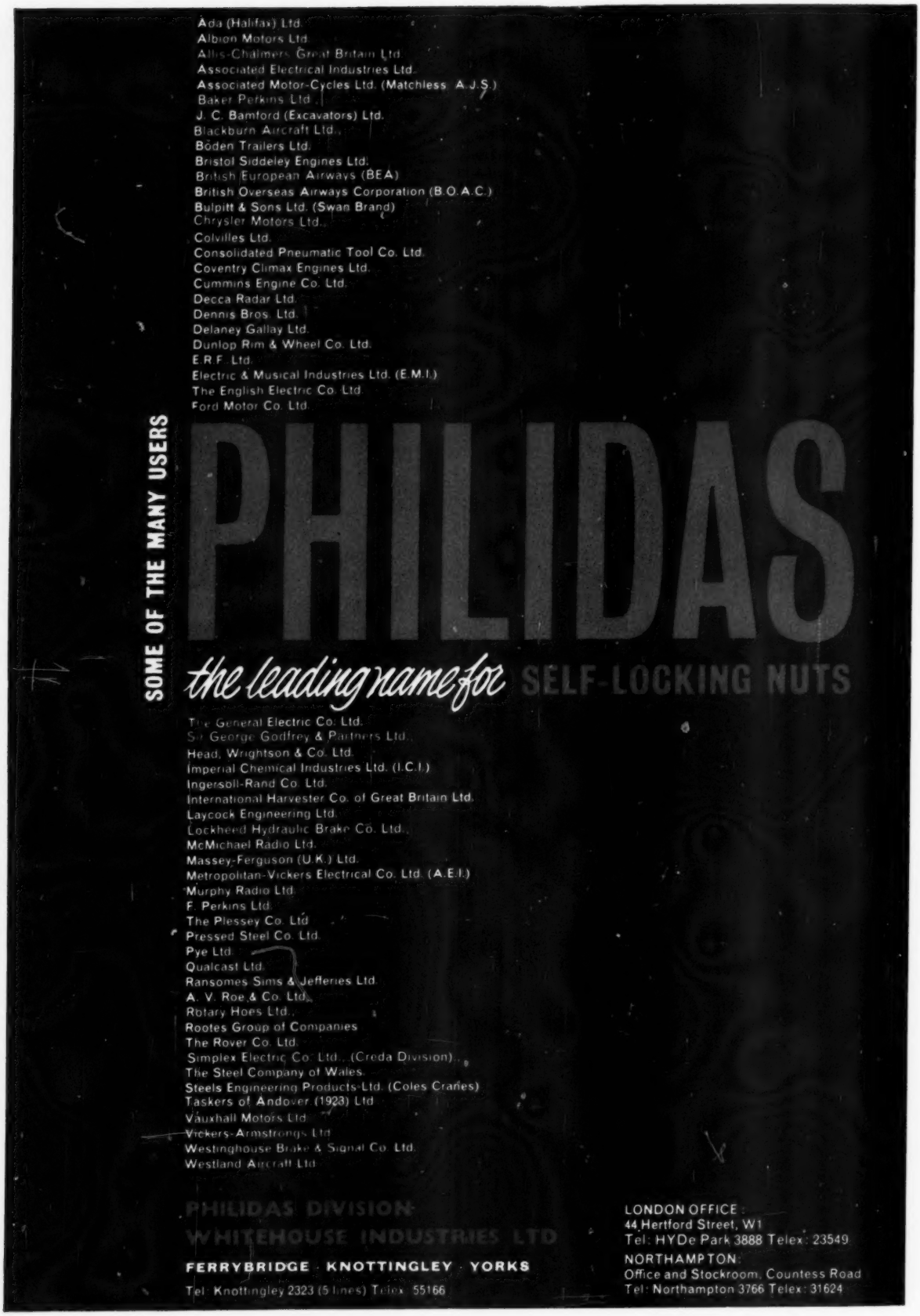
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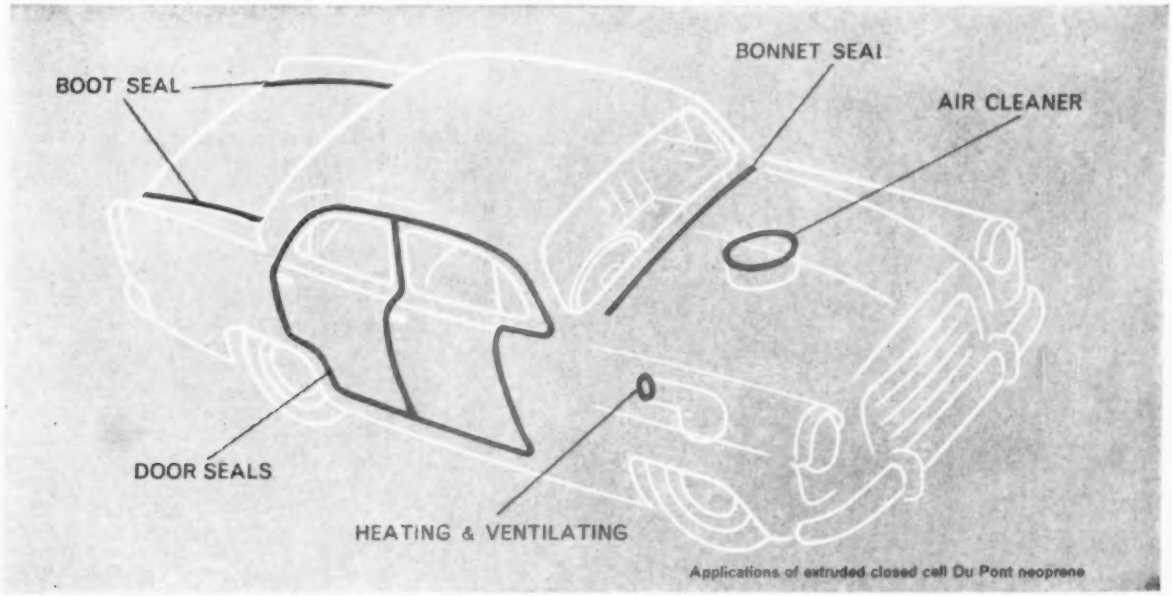

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Examples of complex cross sections which can be extruded

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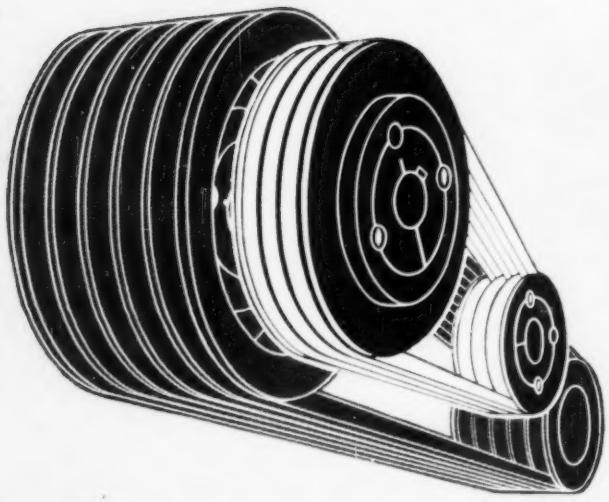

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- Modern materials and a new belt section give a much greater power capacity. SpacesaVer Wedge-Belts make full use of the strength and flexibility of Terylene cords. These are bonded to a synthetic rubber which keeps them exactly where they can do most work with least stress to themselves. This rubber provides heat and oil resistance and adequate electrical conductivity at no extra charge. New pulley designs take full advantage of modern casting methods to give stronger, yet lighter pulleys. All have Taper-Lock quick and easy fixing facilities.
- Two Wedge-Belt sections, $\frac{3}{8}$" (Alpha) and $\frac{5}{8}$" (Beta) cover all normal drives up to 200 horse-power. Belt lengths and pulley diameters are based on International Standardisation principles. Your complete drive design can be selected from a single line reading in the SpacesaVer catalogue 135/20. Send for it now.

THE GREATEST ADVANCE IN DRIVE DESIGN FOR 30 YEARS

HERE IS THE PROOF

DRIVE		MOTOR PULLEY DIAM.	DRIVEN PULLEY DIAM.	FACE WIDTH	V-BELTS AND WEDGE-BELTS USED	CENTRE DISTANCE	DRIVE LIST PRICE	DRIVE WEIGHT LB.
5 H.P.	V-Belt	$3\frac{3}{4}$	$6\frac{3}{8}$	$3\frac{1}{4}$	5—A29	7·5	£6 · 8 · 7	16·7
	Wedge-Belt	3·15	5·60	$1\frac{1}{4}$	3 Alpha 280	7·1	£5 · 3 · 8	10·6
	SAVING	**16%**	**12%**	**54%**	—	**5%**	**19%**	**36%**
25 H.P.	V-Belt	$6\frac{1}{2}$	$12\frac{1}{2}$	$5\frac{7}{32}$	6—B65	18·7	£17 · 0 · 7	66·8
	Wedge-Belt	5·3	10·6	$2\frac{23}{32}$	6 Alpha 560	15·3	£11 · 11 · 6	36·2
	SAVING	**18%**	**15%**	**48%**	—	**18%**	**32%**	**45%**

SpacesaVer **WEDGE-BELT DRIVES**

MADE ONLY BY

Fenner

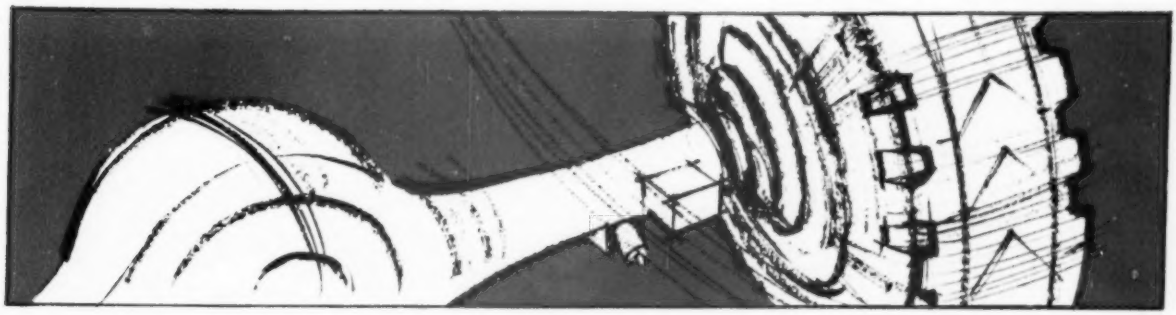
J. H. FENNER & CO. LTD. HULL

Catalogue 135/20 details drives up to 200 h.p. Send for it NOW!

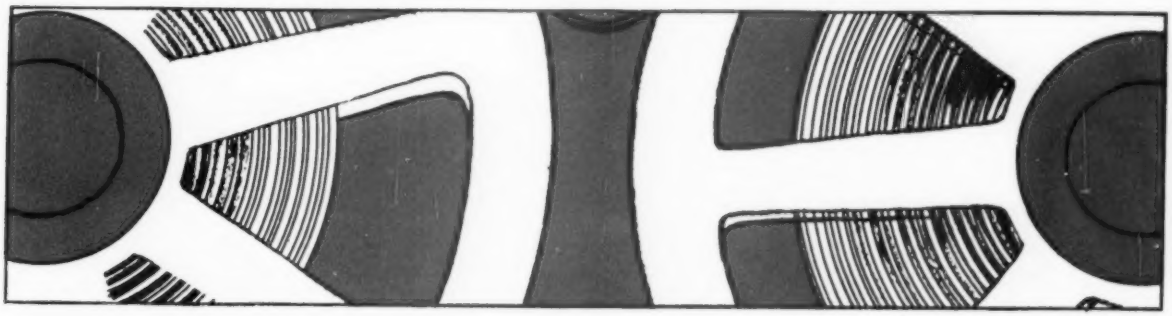
NAME AND POSITION .....

FIRM'S ADDRESS .....

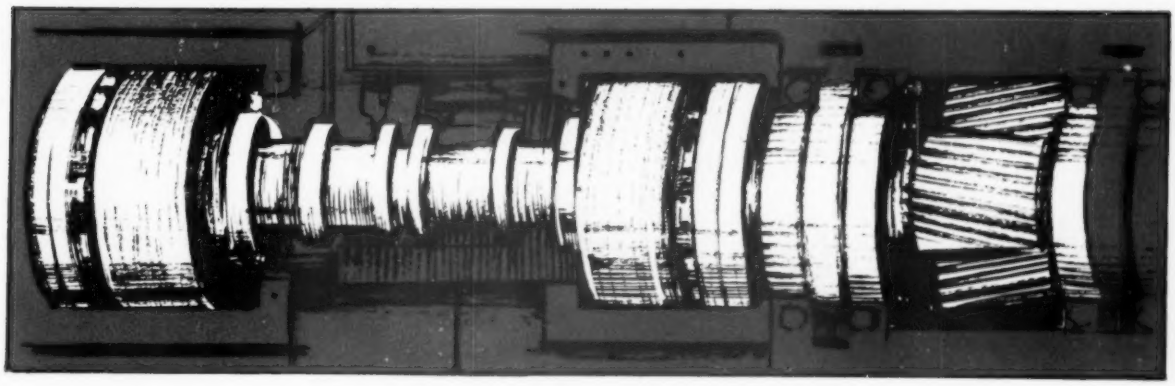
THE LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH



consult R&M bearing experts



when at the prototype stage



As machines grow more complex and performances increase, the selection of bearings becomes more difficult. It requires specialist knowledge.

In increasing numbers, design and development groups are consulting the Technical Department of Ransome & Marles for guidance. Specification as well as supply is part of the R&M service to the engineering industry.

Every enquiry gets equally impartial and confidential consideration. Every project benefits.

Ransome & Marles produce ball and roller bearings for most applications.

Publication 37 is a comprehensive guide to the full range.

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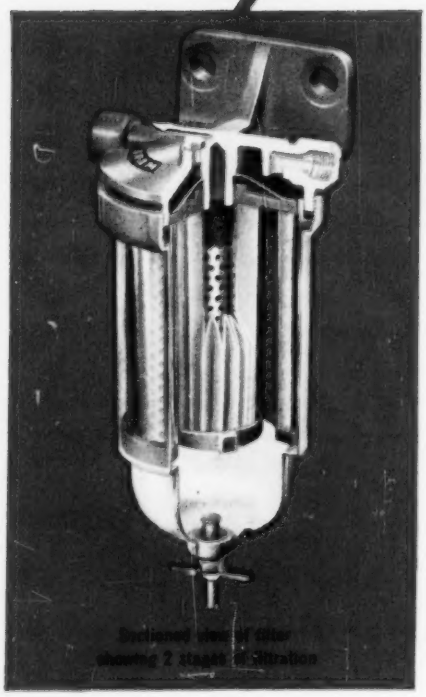

FRAM TWO STAGE WATER SEPARATOR FUEL FILTER FOR DIESEL ENGINES

Simmonds Aerocessories Limited supply this new Fram Filter to the Ford Motor Company as an optional extra for diesel-engined Thames Trader Trucks. The filter ensures a perfectly clean stream of fuel, trapping dirt down to five microns in particle size and removing entrained or emulsified water.

Available also for fitment to trucks already in use, the unit is compact and easy to install and the replacement elements can be changed without tools. Send for illustrated leaflet giving full details.

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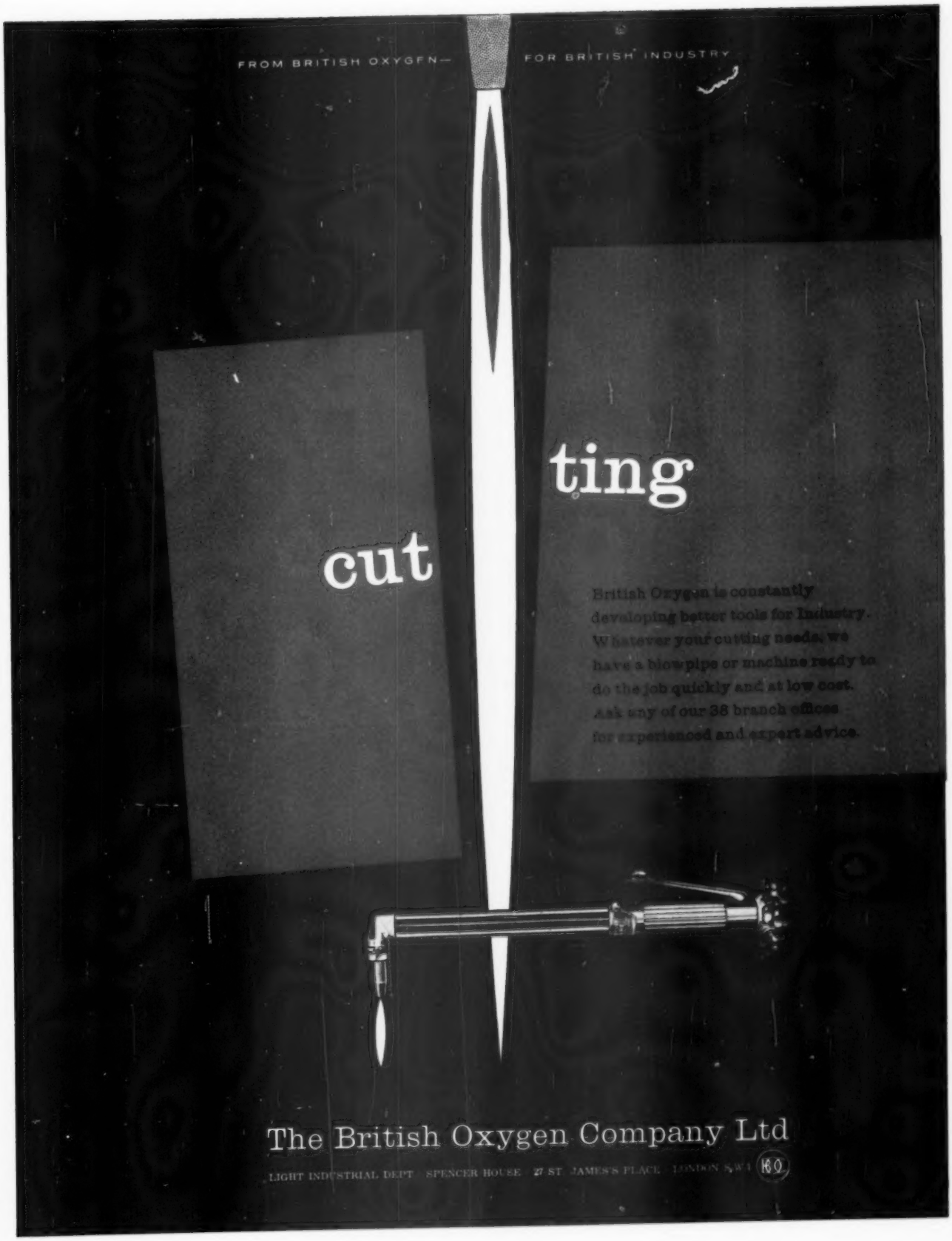
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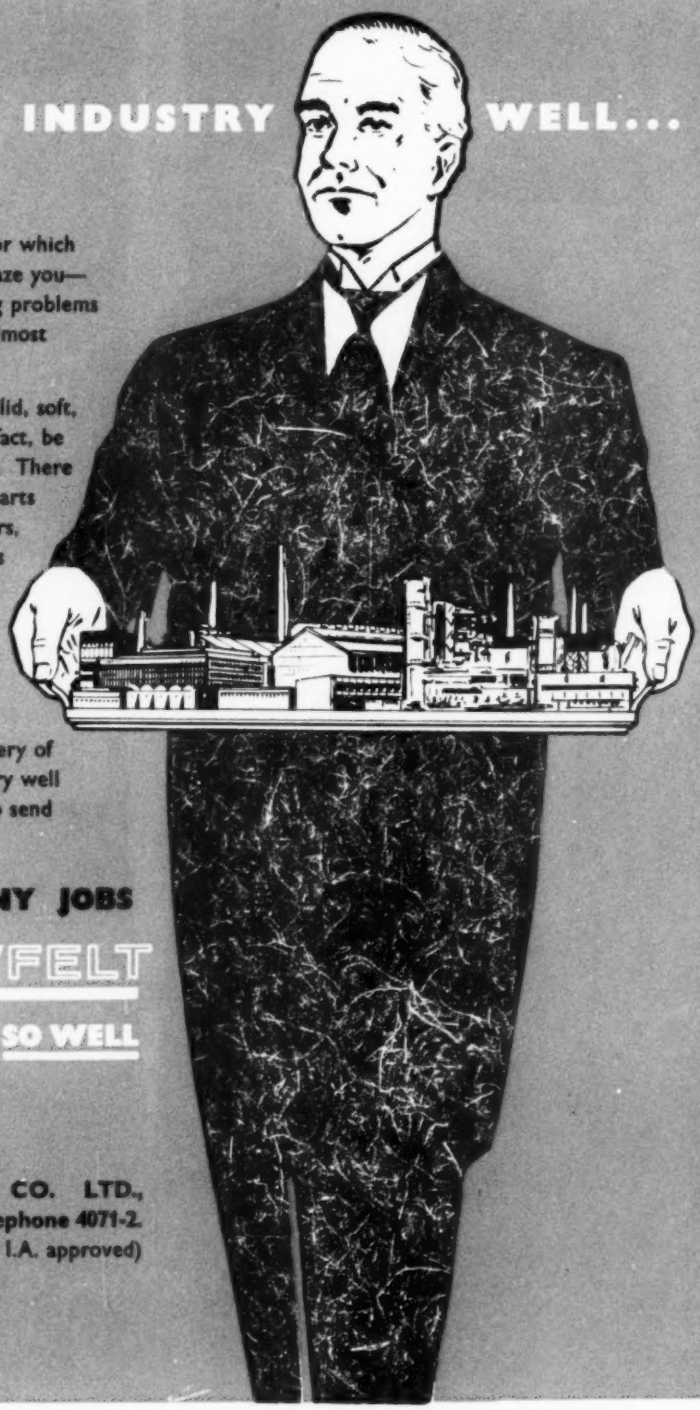

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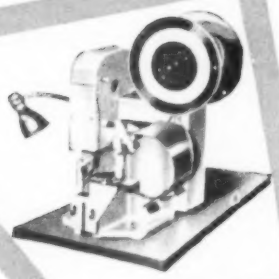
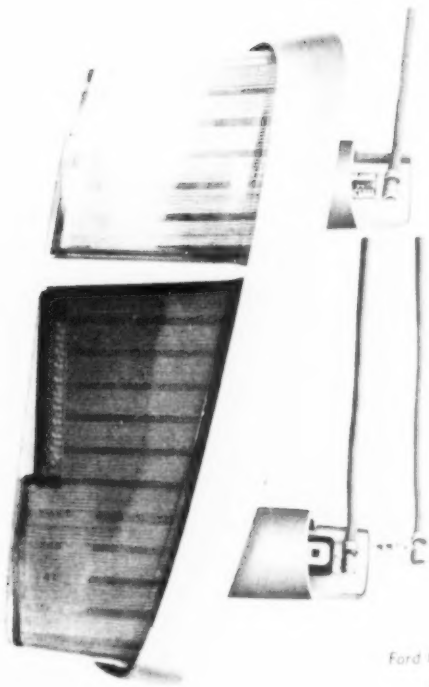
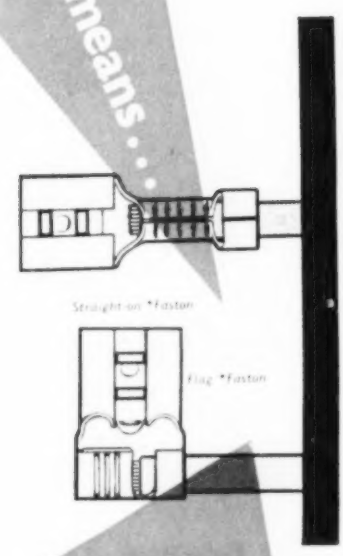


the means . . .



Thames Van rear lamp assembly



Straight-on *Faston

Flag *Faston

Ford Consul de Luxe — Electrical system uses both straight-on and flag* Fastons

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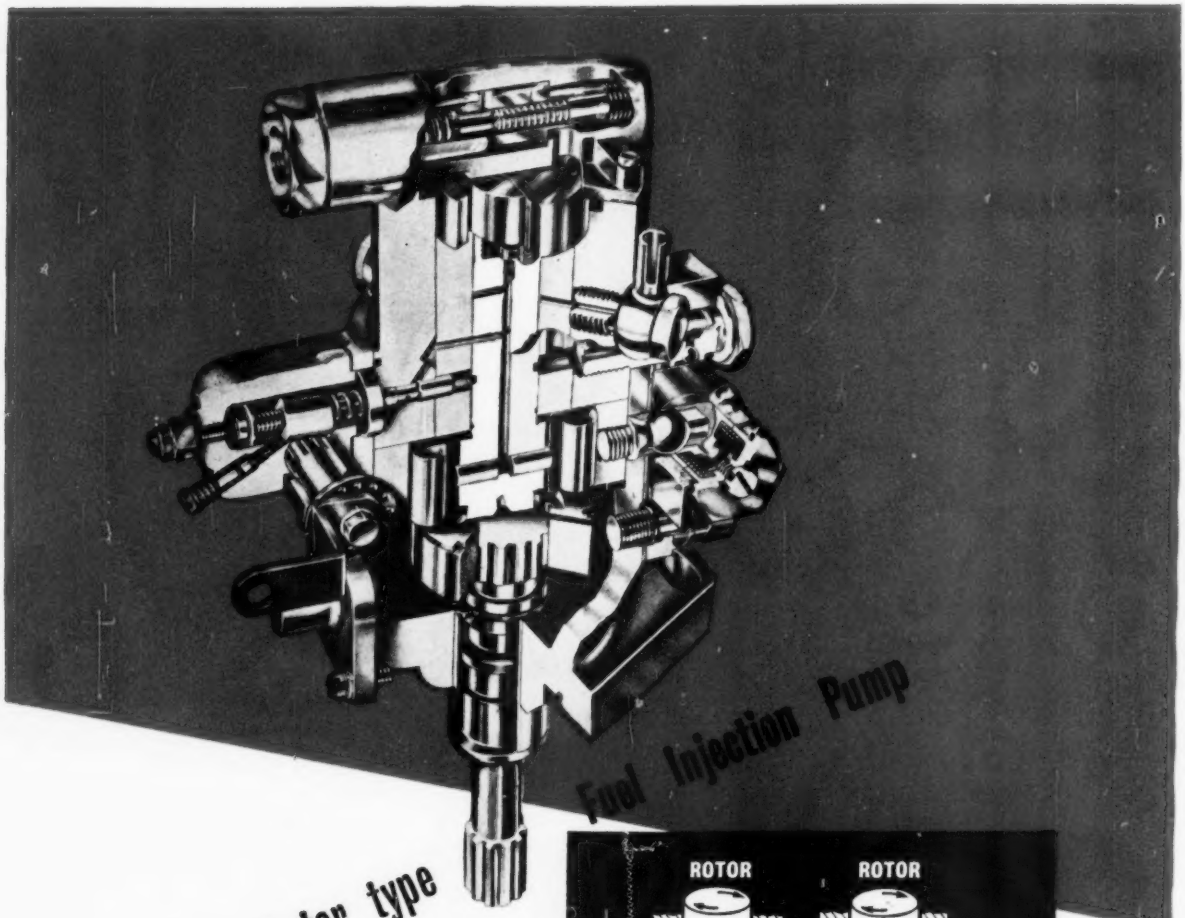
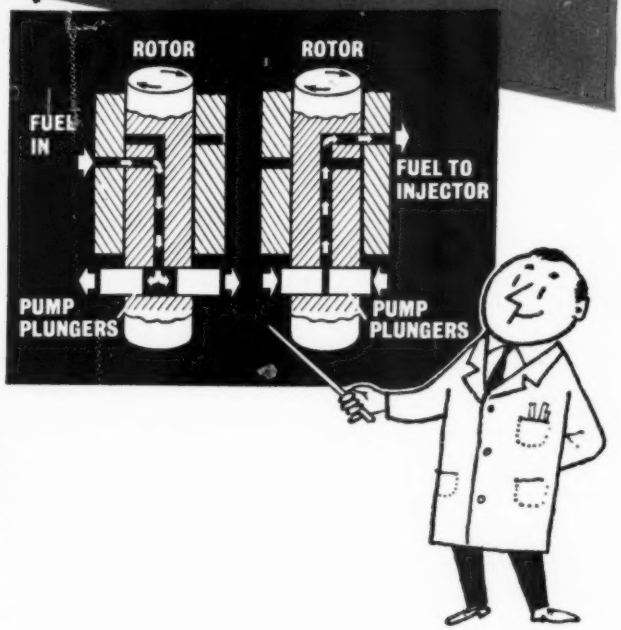


The Distributor type Fuel Injection Pump



THE SIMPLE BASIC PRINCIPLE

The DPA pump is quite simple in operation. It has only ONE pumping element, whatever the number of engine cylinders. Twin opposed plungers carried by the rotor are operated by a cam ring. The rotor is carried in a stationary housing, and drilled ports provide for fuel inlet and discharge. The left diagram shows fuel entering the pumping element on the inlet stroke. As the rotor turns (right), the inlet port is shut and fuel is delivered through one of the connections leading to the injection nozzles. This cycle is repeated for each engine cylinder, the rotor distributing charges of fuel to each outlet in turn. No calibration or phasing adjustments are required.

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Are you concerned about the effect of this sort of treatment on its amenable behaviour?

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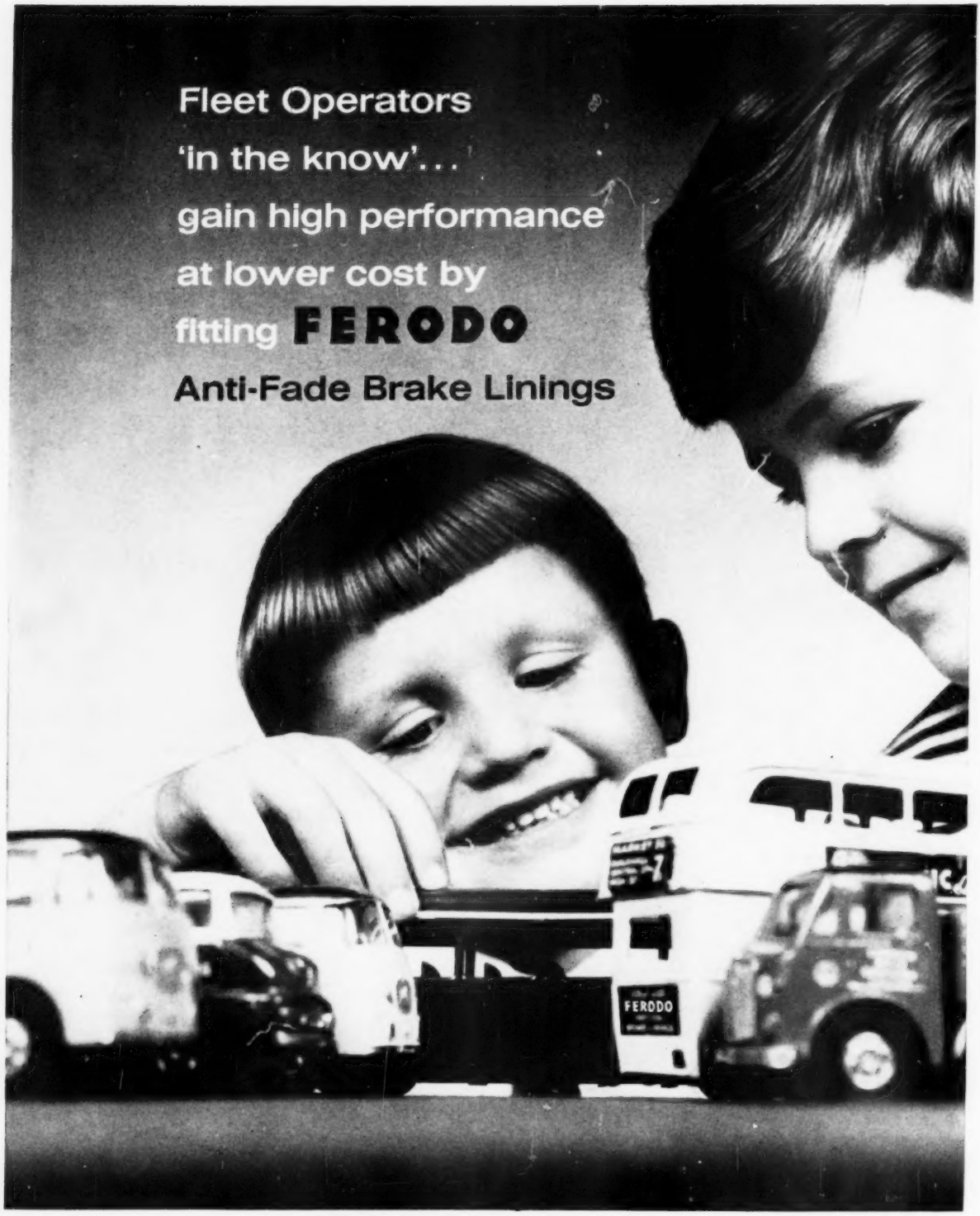

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Anti-Fade Brake Linings First-to-last

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INSIDE LOOKING OUT: and to this grille, the weather looks just fine. It's made from Alcan Aluminium ingot, and aluminium is rust proof right through.

Canada casts a weatherproof eye at winter motoring

Not so long ago, the front of a car came through the British winter looking as if it had measles. Attacked by thirty-five inches of rainfall a year (thrown up by the cars ahead in the form of corrosive road-slime), the grille and trim soon lost their newly minted appearance, and came out in speckles of rust. Rust that was often so unsightly that a recoating or even a replacement was needed.

For many a British motorist, that is past history, because manufacturers are swinging over to grilles and trim of *aluminium*. Aluminium is inherently rustproof, *immune* to rain and road slime—and even salt water.

And an aluminium grille is *all* aluminium, produced from the pure metal itself—it's not just a surface plating. Scratches don't turn into rust marks a day or two later. (Londoners who have to park their cars out of doors may find the aluminium grille outlasts the car!) It's easier to clean, too. Just wipe with a cloth and it's as good as new. All this means that a car finished in aluminium is *worth* more—when you buy it, own it, sell it.

Alcan and Aluminium. As the leading British suppliers of this beautiful metal, with the biggest research laboratories in Europe, we are finding new uses for aluminium in car manufacture—new kinds of anodizing that will make it still more attractive, new ways to cast and forge it. These, and many more advances, will find their way into the car you drive . . . to your advantage.

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Britain's most widely used aluminium

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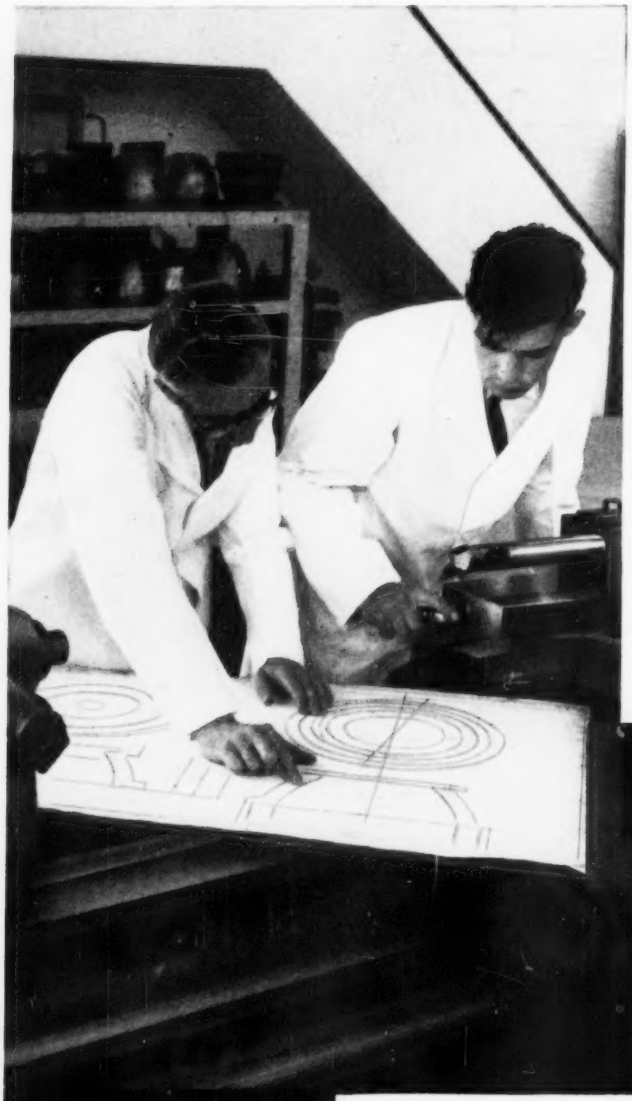
Workshop angle and D.O. viewpoint



Now that machining costs are so high, the legibility of working drawings has become of supreme importance. ILFORD Azoflex photoprinting papers give maximum legibility combined with speed of production and long life in normal storage and use. That is the workshop angle combined with the viewpoints of the drawing stores and D.O.

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Photograph by courtesy of Duraglass Limited

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Many business and industrial concerns find that it pays to hire certain AZOFLEX machines — rather than buy them outright. Enquiries will be treated with the utmost discretion, and will not commit you in any way.

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For Extreme Accuracy and High-Production Surface Grinding...

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MODEL 96LE

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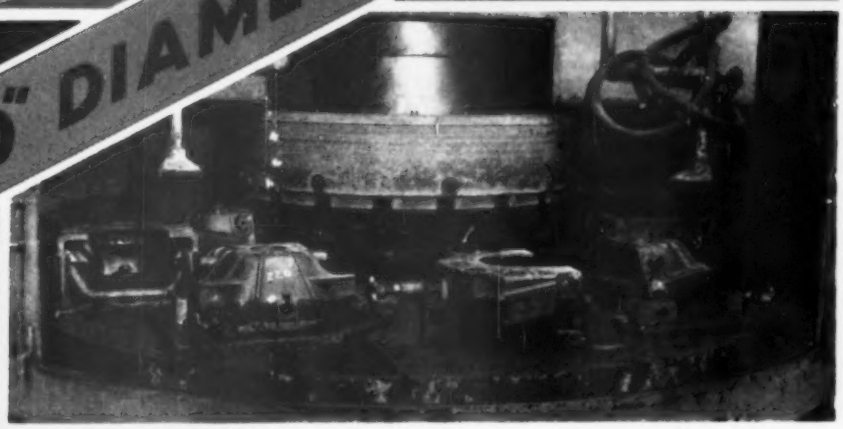

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have three of these machines installed at their Eastfield Works . . . . . .

Grinding eight clutch housings of the 'P' series engines; four housings located for grinding gearbox face and four for grinding engine face. Total time—43·2 mins., thus each housing is ground on both faces in 10·8 mins.

Material is cast-iron. Stock removal up to $\frac{3}{16}$" from each face.

A rapid and economical means of producing accurate, flat surfaces even when heavy stock removal is required.
Spindle speed 300 r.p.m.
Other table sizes available from 24" diameter.

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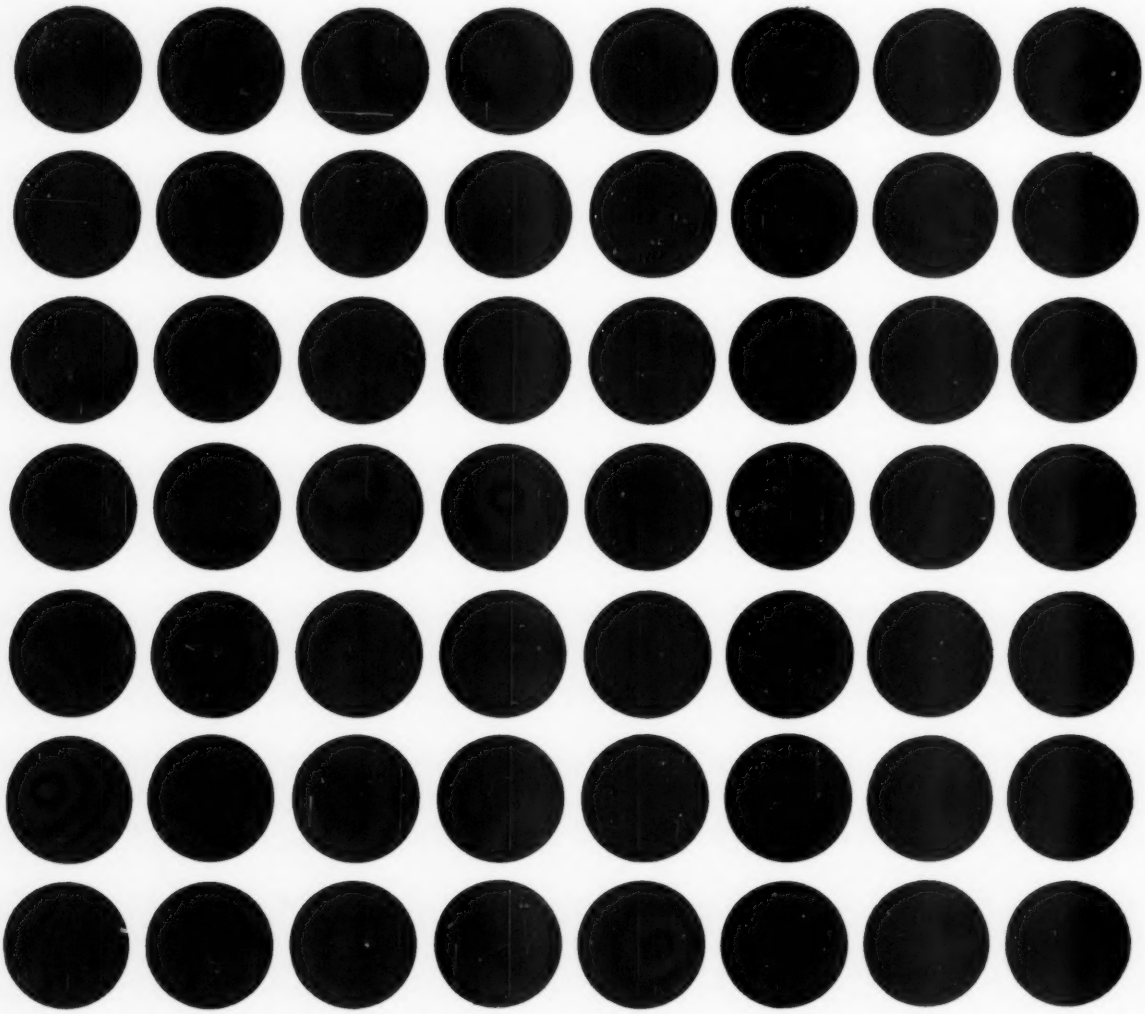

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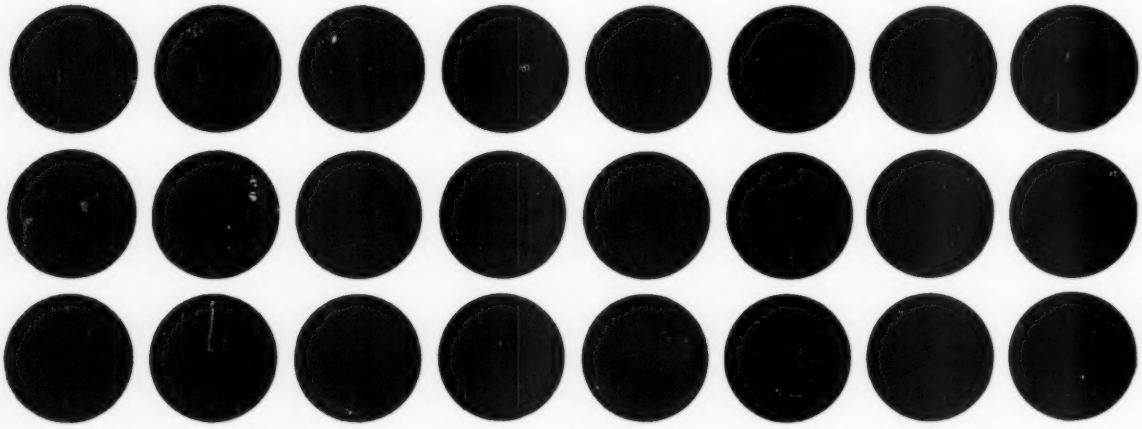

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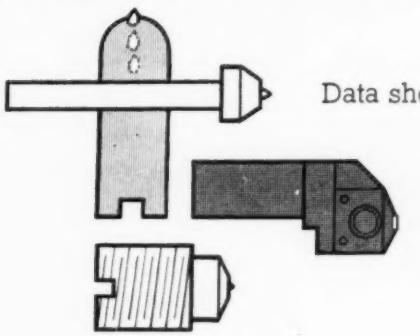

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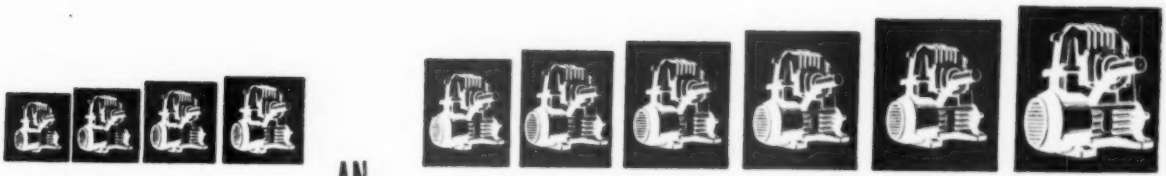

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3½"

The new Holroyd 3½" centres Worm Speed Reducer will in future take its place between the present 3" and 4" sizes in our standard range of gear boxes. Its purpose is to fill the rather wide gap in power capacity which previously existed between the 3" and 4" sizes. Thus it will give you more latitude in choice of reducers and greater economy in those many instances where it happens to suit the power requirements of your application. It is built to the same high standards as all the other gear boxes in our range. Please write for details.

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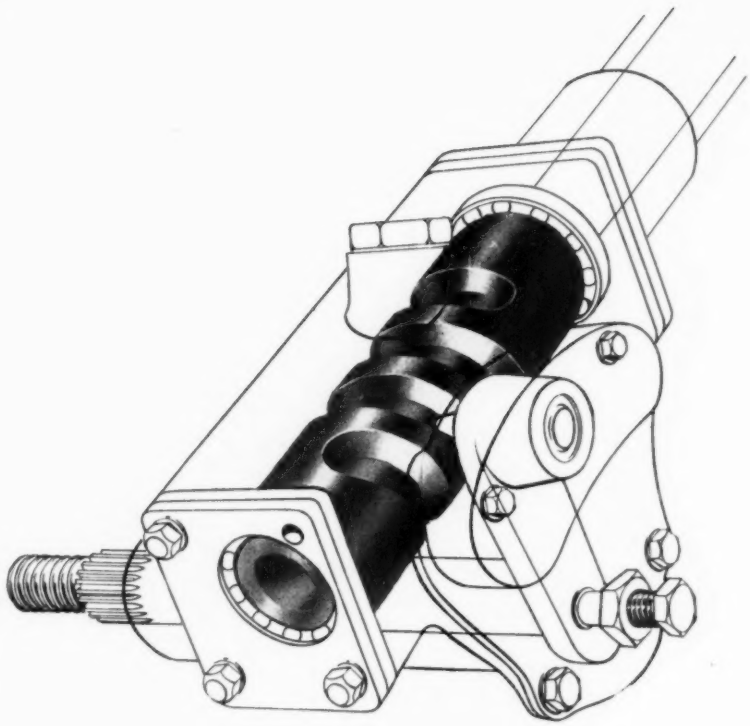

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Isolating road noise

It is the *volume* of rubber that is the determining factor in isolating road noise.

Here are two very successful Metalastik components; the Contrasonic spring shackle, evolved for the 3-litre Rover and the Metaxentric bush. The construction of the Contrasonic shackle is self-evident, also the canting of the twin units to resist lateral stresses. Fore-and-aft movement, as the leaf spring changes in length, is accommodated by the rubber in shear; weight by combined compression and shear.

A Metaxentric bush in the front eye of the spring and a Contrasonic shackle at the rear provides the most effective barrier yet devised against the transmission and amplification of noise.

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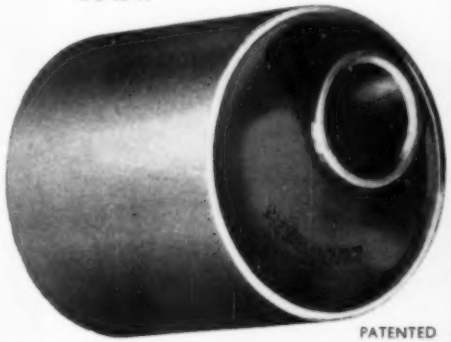
First fitted in spring eyes by the Standard Motor Company, Metaxentric bushes give much higher vertical deflections than concentric types. In fore-and-aft directions they are stiffer than in the vertical plane, the ratio being about 2·5 to 1.



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HERE ARE 7 DIFFERENT C.P DRILLS

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If you are dealing with $\frac{3}{16}$" holes on light construction work, or 3" holes on heavy engineering—CP make the drill you need for the job. For drilling, reaming, tapping or tube expanding—there are CP drills in speeds to suit any operation.

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Difficult shapes are welcome. With years of experience in design and manufacture, we can supply the most complicated boots and gaiters to close tolerances and in exactly the right rubber (natural or synthetic) for maximum resistance to oil, chemical attack, ageing and extremes of temperature. We will be glad to undertake the design of components.
In addition to Boots and Gaiters, John Bull products include Convoluted Hose, Shaped Hoses and Rubber Mouldings.

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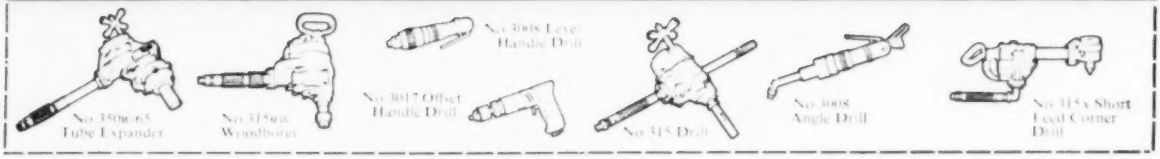
The right DRILL for the job... ...and CP make it!

HERE ARE 7 DIFFERENT C.P DRILLS


No. 3508/65 Tube Expander
No. 315RHS Woodborer
No. 3005 Level Handle Drill
No. 3017 Offset Handle Drill
No. 315 Drill
No. 3008 Angle Drill
No. 315/s Short Feed Corner Drill

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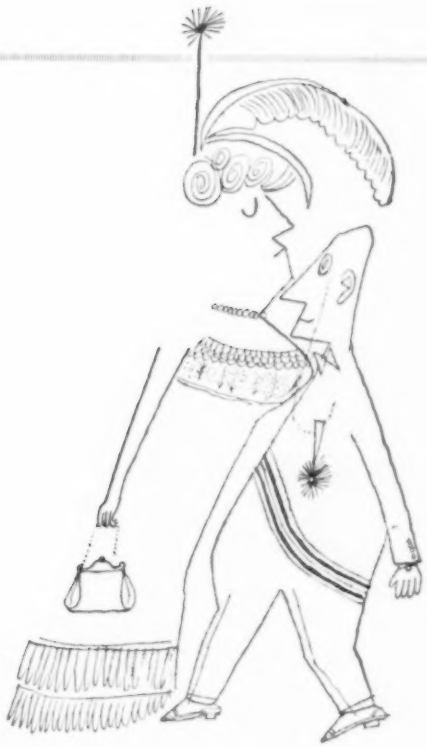

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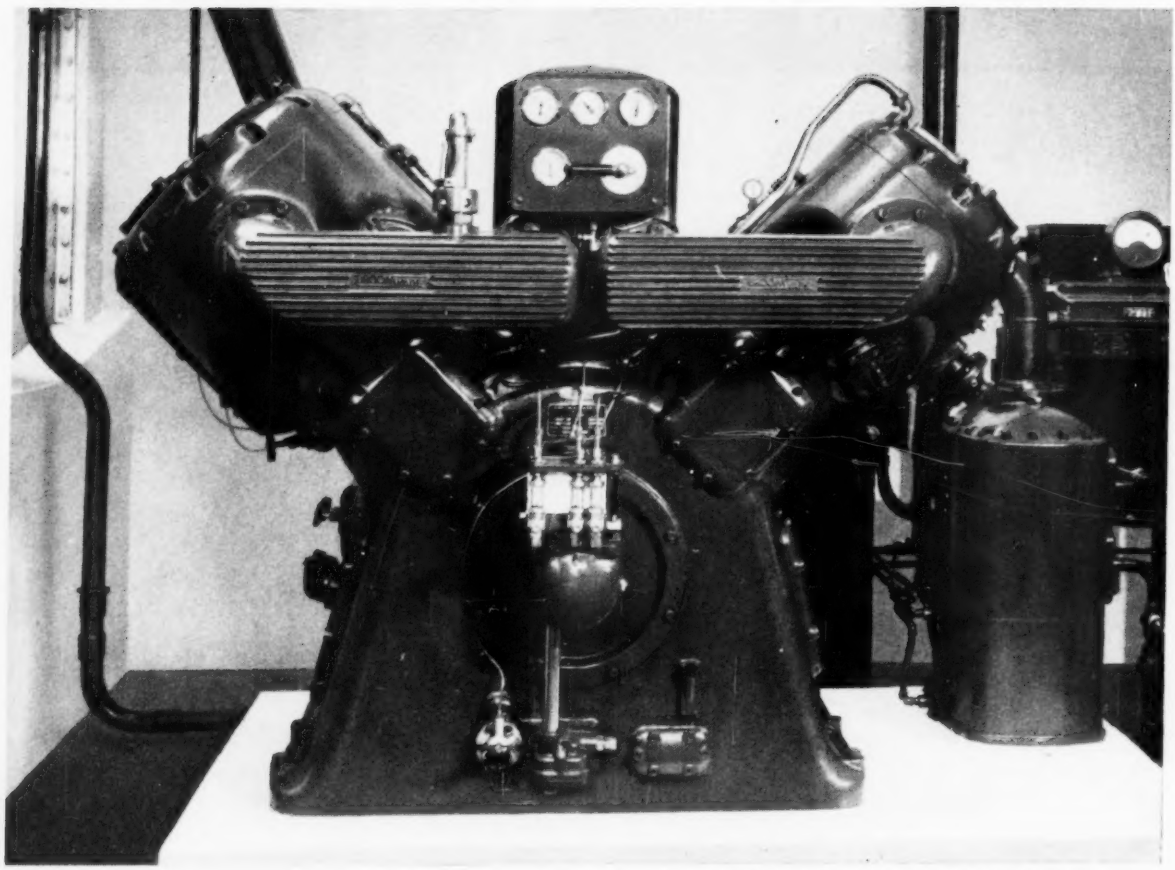

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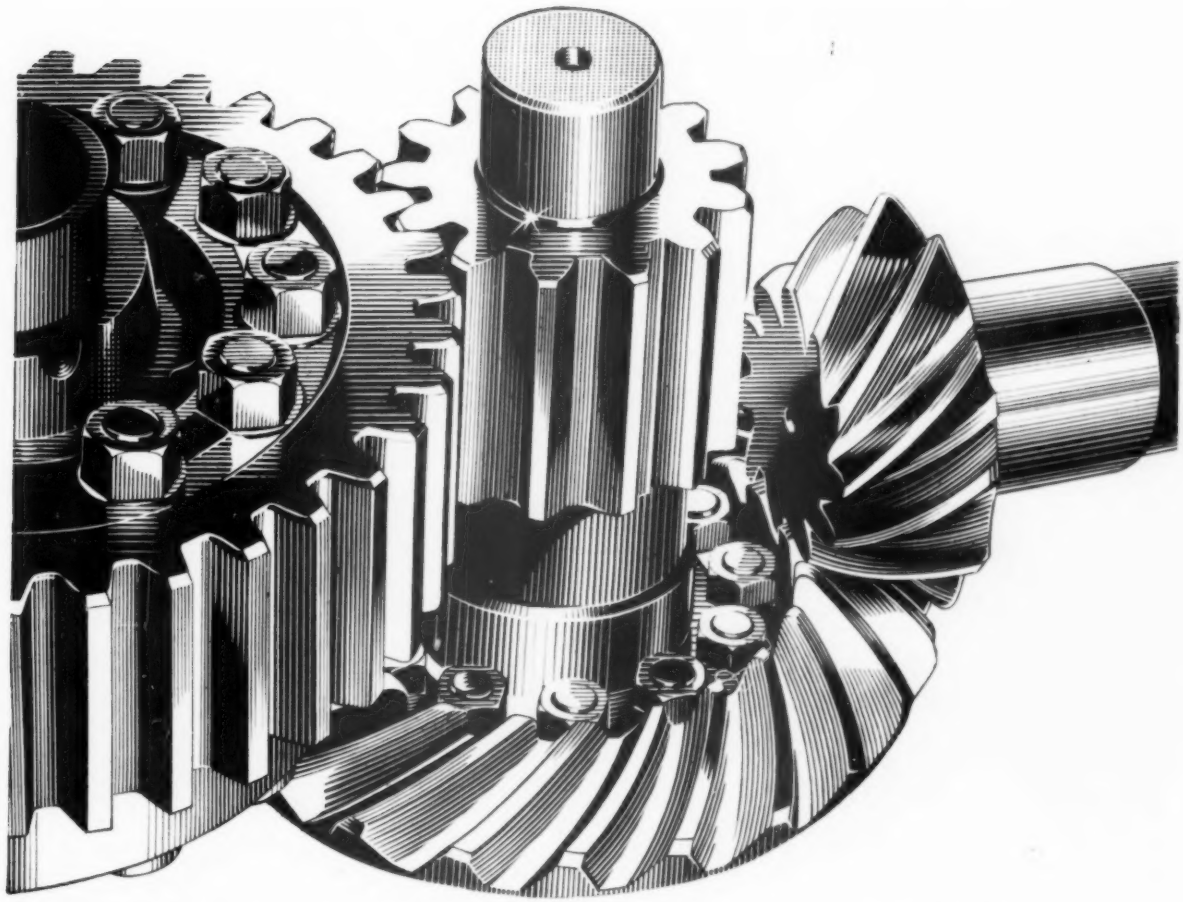

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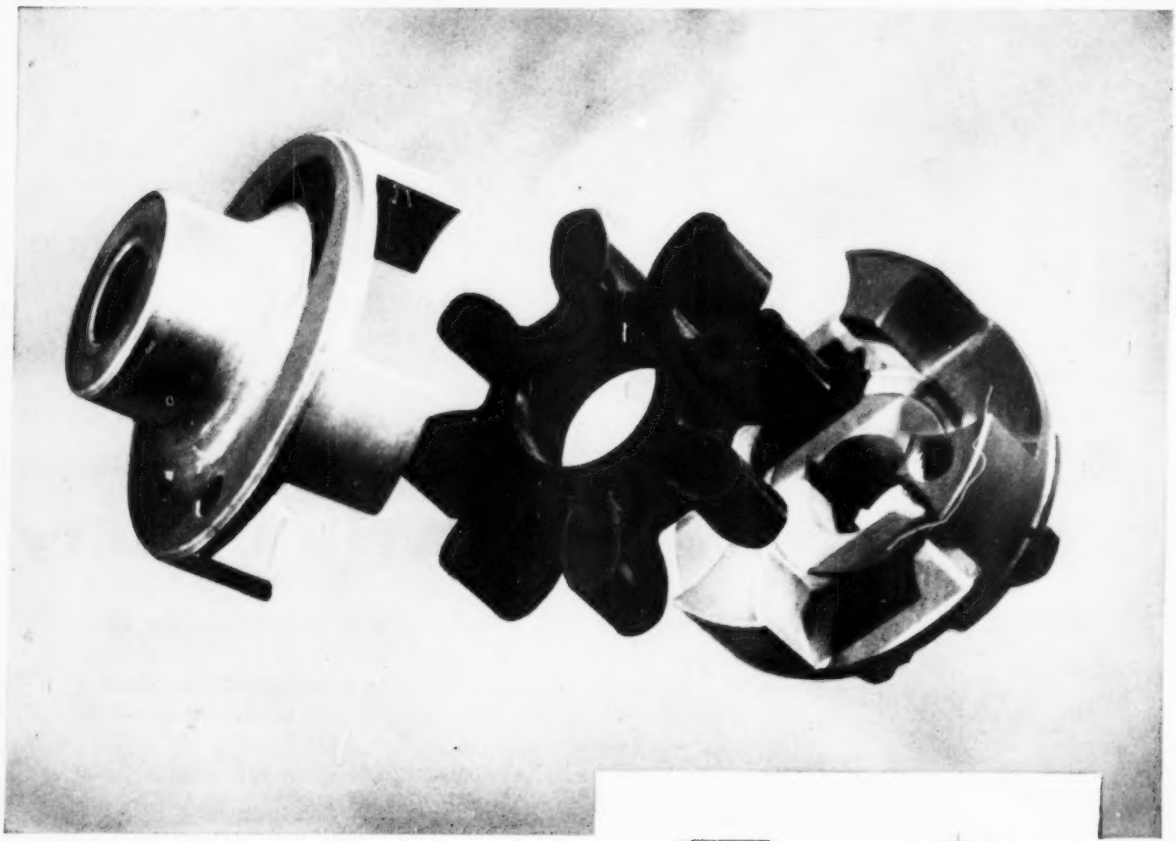

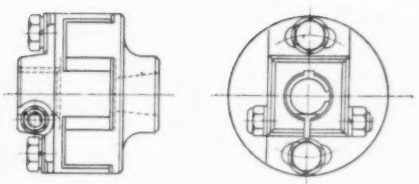

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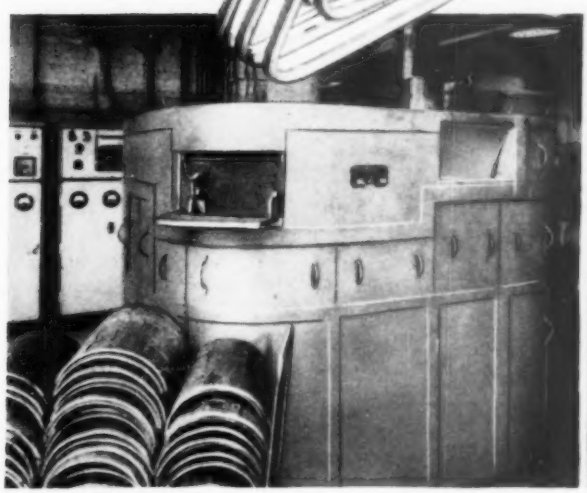

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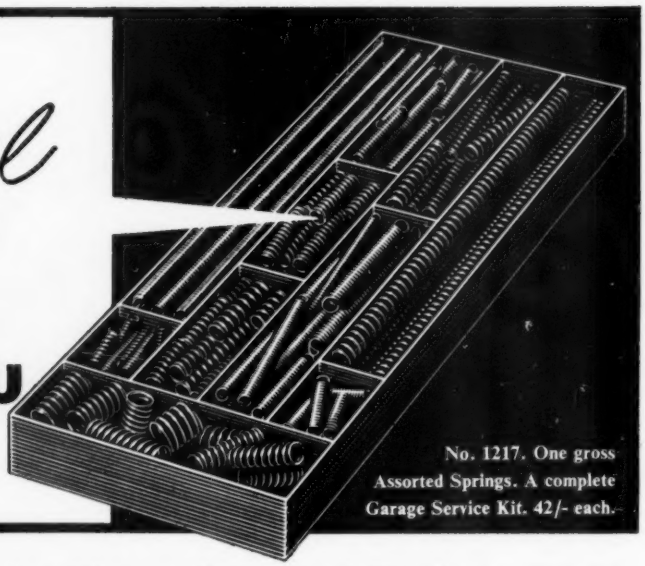

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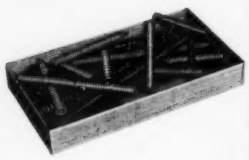

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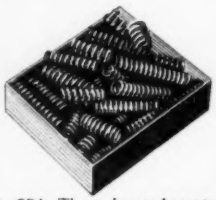

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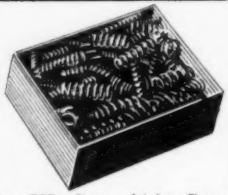

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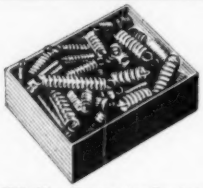

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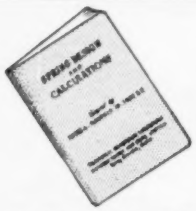

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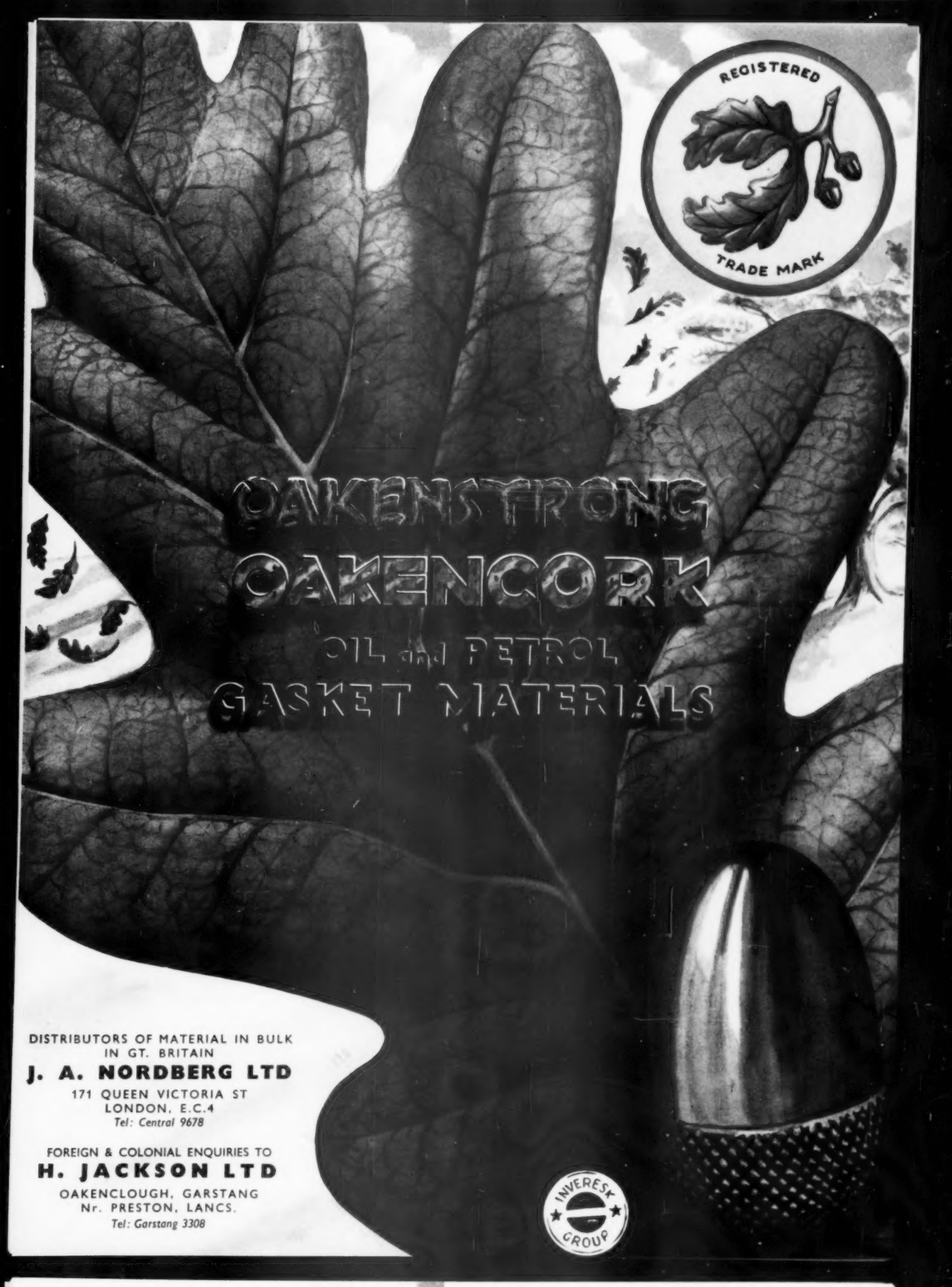

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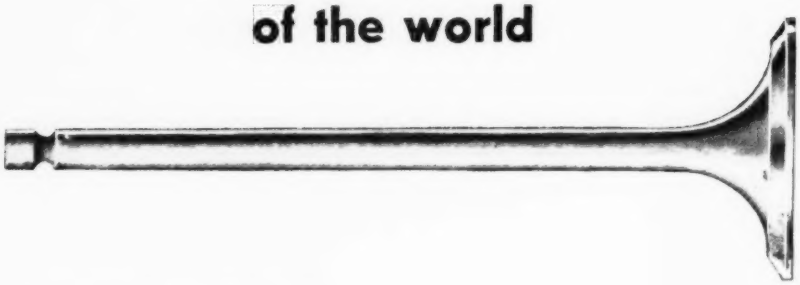

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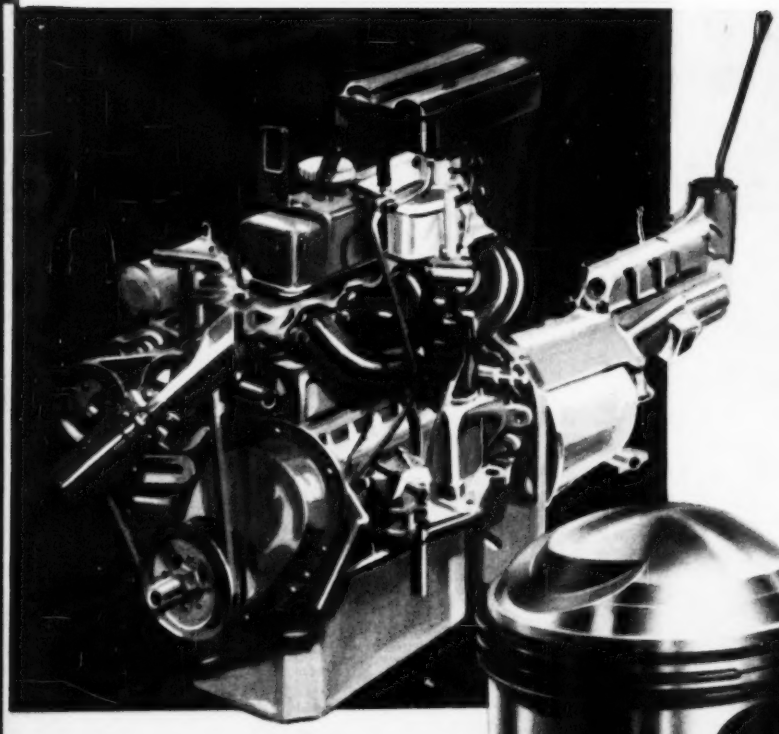

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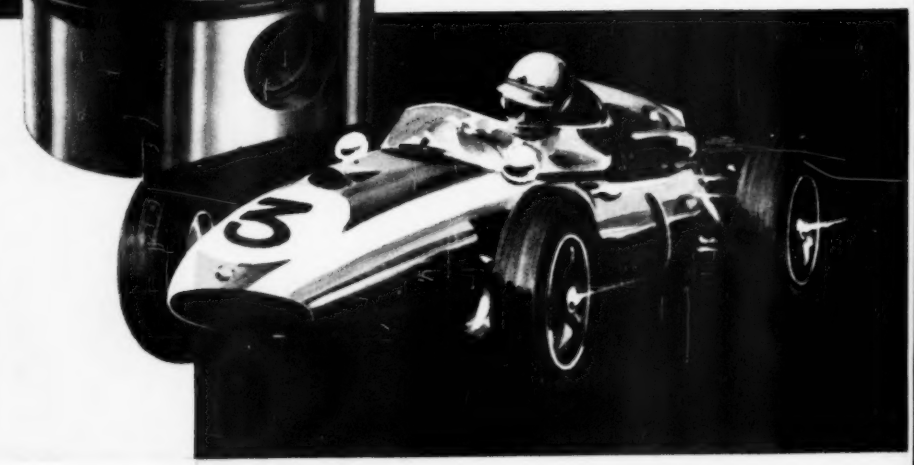

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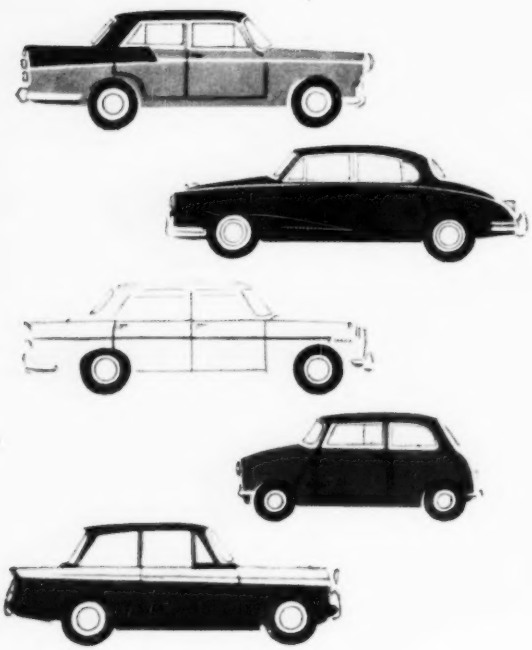

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AUTOMOBILE ENGINEER

CONTENTS

523 Editorial *Technical Sales Policy*

524 Hydra-Matic 61-05 Transmission *Part 1: Mechanical components and power flow of the new General Motors automatic unit, which is offered as optional equipment on Vauxhall 2·65 litre cars*

532 P.S.V. Heating and Ventilation *Part II: Sources of heat, bus heating systems, and overnight parking requirements* H. BJÖRCK

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A FEATURE OF THE HYDRA-MATIC 61-05 AUTOMATIC TRANSMISSION IS THE USE OF A FLUID COUPLING EMBODYING A TORQUE MULTIPLIER ELEMENT, WHICH IS SHOWN HERE. THE MULTIPLICATION OBTAINED BY THIS COMPONENT IS 1·30 : 1

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Technical Sales Policy

BEFORE the Second World War, most of the major car manufacturing companies in Great Britain had well defined policies regarding the sales appeal of their products. Several, for example, placed emphasis on high performance: of these, some have since endeavoured to retain their reputation in this respect while, in fact, making considerable concessions in the interests of rationalization of production; others have steadfastly maintained their tradition of placing performance first, and at least one has been highly successful in reconciling the requirements for the continuance of this tradition with those for production in relatively large quantities.

Of another manufacturer's cars, it was widely said that they were supreme so far as reliability was concerned. Yet another achieved phenomenal success as a result of outstandingly good organization of servicing facilities, and of course there are also those firms who have made enviable reputations by virtue of the superb luxury and craftsmanship of their products.

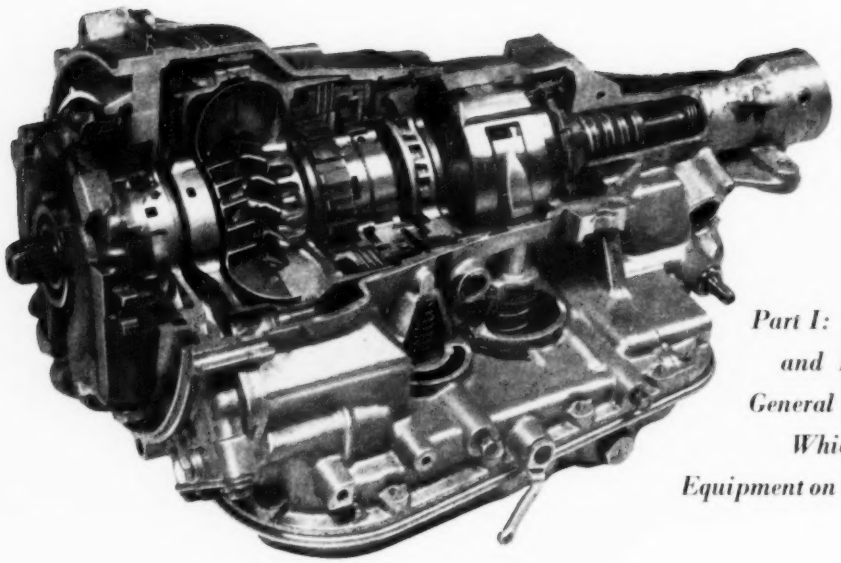
Since the War, however, with a few exceptions, there has been little evidence of any attempt to pursue a positive line of approach to the market, with a view to establishing a reputation for supremacy in any one field. Instead, there is a general uniformity of merit among the quantity produced cars that comprise the overwhelming majority from which the customer must choose.

It undoubtedly will be said, however, that customers now take reliability for granted and expect, no matter what car they buy, first-class servicing facilities, high performance, economy of operation, low cost, good quality, comfort, and smart and attractive apearance. Nevertheless, the fact remains that some of these qualities are irreconcilable, and there is still plenty of scope for individual manufacturers to build up exceptionally good reputations in one field, without making significant sacrifices in any of the others. For example, while high performance inevitably entails some sacrifice in respect of economy, the fuel consumption need not be so much higher that the customer will reject the faster car in favour of one of more modest performance from a competing manufacturer.

There are some people, of course, who aver that high performance is not required of the family saloon, because they never do much more than 60 m.p.h. This is faulty reasoning, especially in the light of projected extensions to the motorway systems in many parts of the world. In any case, the driver who is doing 60 m.p.h. is considerably reassured if his car is capable of doing 80 m.p.h. so that he is not operating the mechanism anywhere near its top limit and therefore stressing it unduly; he is also comforted by the knowledge that he has plenty of power in hand for momentary acceleration should the need arise.

On the subject of reliability, it is true that in general the standard is so high that it would be difficult to make significant improvements in many respects. However, there is one field in which much can be done: it is in that of the reliability of the car when new. Failures and defects on new cars cause considerable loss of goodwill and could be largely avoided by systematic inspection: more attention should be paid to servicing departments' lists of defects commonly experienced on new cars, and specific measures for their avoidance should be made effective by production and inspection departments.

Much can be done to reduce servicing costs, which will become increasingly significant in the coming age of automation, when labour costs can be expected to become prohibitive. An obvious measure is the complete elimination of maintenance in respect of certain components: in this connection, much has of course already been done so far as lubrication is concerned. A more complex problem is design specifically for ease of maintenance: among the features needing attention are the employment of quick-release devices instead of more conventional fasteners, the design of inexpensive sub-assemblies which, when defective, can be thrown away and replaced instead of serviced, and more detailed study of installation layout for ease of replacement. Indeed, even in the few spheres that have been mentioned in this article, there is plenty of scope for the development of individual technical sales policies.



This view of a part-sectioned Hydra-Matic 61-05 transmission reveals most of the mechanical components. The oil pump is at the left-hand end, ahead of the fluid coupling, behind which is the clutch of the front epicyclic gear train. Between this clutch and the brake band of the rear gear set is the reverse clutch

Part I: Mechanical Components and Power Flow of the New General Motors Automatic Unit, Which is Offered as Optional Equipment on Vauxhall 2·65 Litre Cars

HYDRA-MATIC 61-05 TRANSMISSION

A MAJOR step towards the eventual general adoption of automatic transmission systems on cars of the sizes manufactured in Europe has been taken by the American General Motors Corporation, with the introduction of an entirely new layout expressly designed for use with engines of about 2½ litres swept volume. This latest addition to the Hydra-Matic series, designated type 61-05, is fitted to the 1961 Oldsmobile compact car, and is offered as optional equipment on the Vauxhall Cresta and Velox 2·65 litre models. For the present, the transmissions are being produced at only the corporation's Detroit plant but, if the European demand becomes sufficient, their manufacture on this side of the Atlantic may be considered.

As is well known, the problems of designing an effective automatic transmission system become more acute as engine size is diminished. Because of the lower power : weight ratio of the basic vehicle, the weight penalty of the automatic unit relative to the traditional gearbox must be small if performance is not to be significantly reduced. For the same reason, high losses in a torque converter—acceptable in an installation in which ample surplus engine torque is available in most circumstances — cannot be tolerated. In addition, the correct matching of gear changing speeds to the torque characteristics of the engine is more critical with a small than with a large power unit.

The solution evolved by General Motors is certainly a rational one. For reasons of efficiency, an orthodox torque converter is not employed : instead, the unit embodies a fluid coupling containing a torque multiplier element, which is only effective in reverse and in the lowest of the three forward ratios provided by the two sets of epicyclic gears. The inefficiency often resulting from a high torque multiplication has been avoided by limiting the multiplication to 1·3 : 1, so first gear ranges from 3·64 : 1 to 3·03 : 1. In the intermediate gear, which has a ratio of 1·58 : 1, the fluid coupling is empty and the drive is transmitted entirely mechanically, through a friction clutch. Top gear is direct, and in it the torque is shared between the friction clutch and the fluid coupling, in which the torque multiplier is then inoperative : about ⅔ of the load is taken by the clutch, so high efficiency is ensured.

As on the majority of other transmissions of this type, the changes of ratio are effected hydraulically, the road speed at which they take place being determined by a combination of throttle opening and vehicle speed, as detected by a throttle operated valve and a governor on the output side of the transmission. Changes between the low and intermediate ratios can occur at any speed between 10 and 25 m.p.h, depending on the throttle opening, and the corresponding range for selection of the upper pair of gears is 15 to 55 m.p.h. To avoid hunting between gears, the settings are, of course, such that downward changes normally occur at a lower road speed than do the corresponding upward changes. Full depression, or kick-down, of the accelerator pedal results in a change into the next lower ratio at any speed below the maximum for that gear. The selector lever, mounted on the steering column, has the usual positions for parking, neutral, normal drive and reverse, as well as those for holding the low or the intermediate ratio when, for example, descending a steep hill.

Reference was made earlier to the need for reducing the weight to a minimum. In this respect, the G.M. design team is to be congratulated on having kept the weight of the complete installation to within 30 lb of that of the existing three-speed synchromesh transmission of the Vauxhall cars. This low weight has been achieved by restricting the diameter of the fluid coupling to 7½ in, and by the use of aluminium for the housing and other castings. For purposes of comparison, the Laycock-de Normanville overdrive, available as an optional extra with the standard transmission, adds 35 lb to the weight of the gearbox.

Constructional details

The casing of the transmission unit is in four parts : they are the bell housing, which is bolted to an adaptor plate mounted on the rear of the engine, the main body, the rear extension and the oil sump. Whereas the first three are aluminium alloy pressure diecastings, the sump is a steel

pressing bolted to the underside of the main body and the rear extension. The sump, of course, serves as a reservoir for the hydraulic fluid required by the system; this oil, incidentally, is to automatic transmission fluid type A suffix A specification.

In sequence from the input to the ouput ends of the unit, the main assemblies are: the oil pump; the fluid coupling and torque multiplier; the front gear set, surrounding which is its multi-plate clutch; the cone clutch for reverse; the rear gear set with its band brake; and the governor. The two control valve assemblies, which are bolted to the underside of the casing, are enclosed by the sump. A full-flow oil filter, of the paper element type is also housed in the sump, and the oil is circulated through an external oil cooler of the gilled tube type, mounted at the front of the engine, behind the fan.

The input shaft is made from a steel of U.S. specification known as Armasteel and has a serrated leading end, on which fits the centre of a cush-drive coupling. In this coupling, the torque is transmitted from the driving member, through four chordally disposed helical springs to the driven one; the relative motion of the members is friction damped. The periphery of the driving member of the coupling is secured to the rear face of the flywheel by four set-screws and is located by two dowels positioned mutually at 180 deg.

Mounted on the input shaft, immediately behind the drive coupling, is the sintered iron rotor of the oil pump, which is of the eccentric vane type, having eleven steel vanes disposed radially in slots. To provide the variable output necessary to meet the needs of the transmission, the cast iron stator of the pump is, in face, a slide that is free to move in its aluminium housing, in a plane perpendicular to the shaft axis, thereby altering the eccentricity. In the highest position of the slide, known as the priming position, the pump provides its maximum output, whereas there is, of course, no output when the stator is coaxial with the rotor. The position of the slide during normal running is controlled by oil pressure, applied above or below it. Between the bottom of the slide and its casing are two coaxial helical springs, which hold the slide up in the maximum output position when the engine is not running, thus ensuring full delivery as soon as the pump begins to rotate.

A predetermined oil pressure in the main feed line from the pump is maintained by a spring-loaded regulator valve of the multi-land piston type. The line pressure is applied by a tapping to the end of the piston remote from the spring. From this end of the piston, an axial and a radial drilling form a passage to one of the circumferential grooves. If the line pressure becomes too low, the piston is moved upward by the spring, and this passage registers with another leading to the underside of the oil pump slide. Since, at the same time, an exhaust passage from the upper side of the slide is brought into communication with the return side of the oil circuit, the slide moves upward to increase the pump delivery.

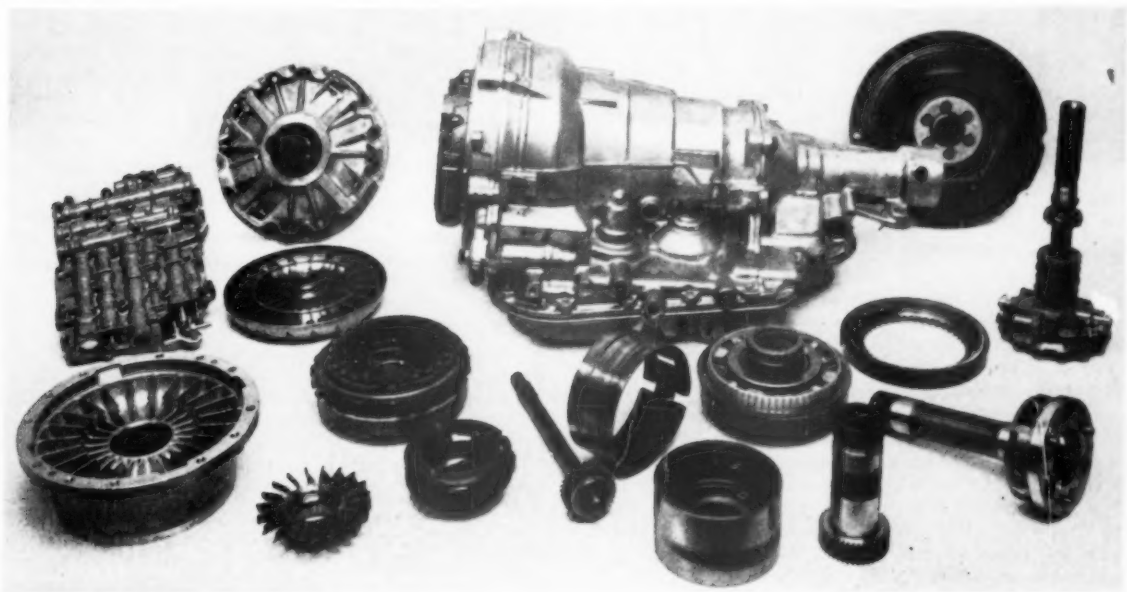
Conversely, if too little oil is being taken by the transmission, the rise in line pressure causes the piston to be moved downward against the resistance of the spring, and the internal passage in the piston aligns with one to the upper side of the slide; simultaneously, the underside is permitted to exhaust, so the slide moves downward and the pump delivery is reduced.

When the transmission requirement is for a higher than normal pressure, oil is delivered behind an auxiliary piston forming the lower abutment of the spring, and causes the piston—and hence the slide—to rise. On the other hand, when a low pressure is required for certain conditions of operation, oil is supplied to an intermediate groove in the piston. Since the land diameter above this groove is smaller than that below it, there is a resultant downward force on the valve, and the pump output is therefore reduced.

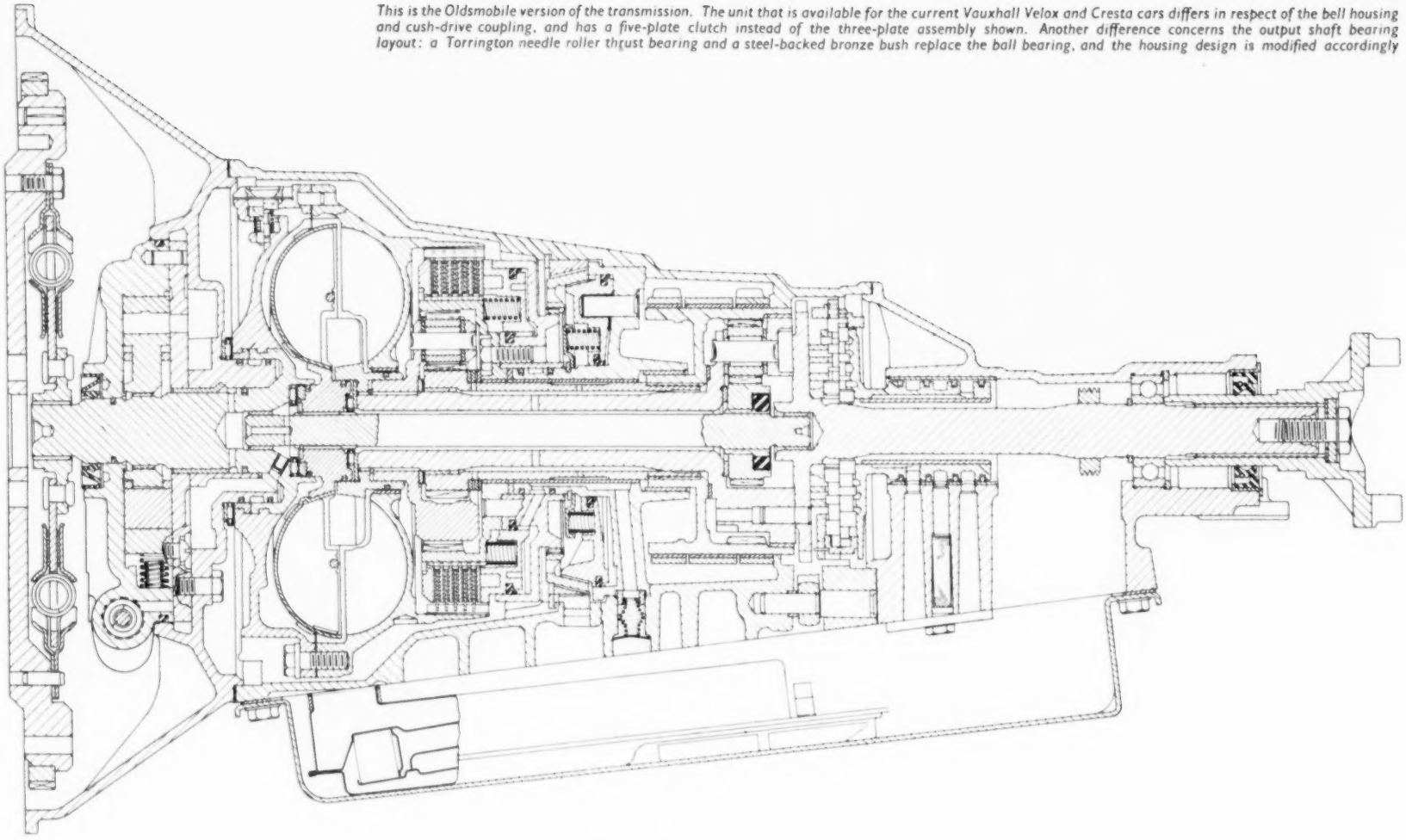
The oil pump housing, in which are the inlet and delivery ports, is bolted to the front wall of the main casing. In the central boss of the wall is a steel-backed bronze bush in which the input shaft is carried. Mounted on the rear end of this shaft is the carrier of the driving member of the fluid coupling; a Torrington needle roller thrust bearing is fitted between the carrier and the casing wall.

The carrier has a deep, rearward projecting peripheral flange, to which is bolted the forward facing half-torus that

The various components of the transmission. On the left, behind the coupling driving member, are the two diecast bodies containing a number of the hydraulic valves used in the control system. In the top right-hand corner is the resilient coupling that transmits the drive from the engine flywheel



This is the Oldsmobile version of the transmission. The unit that is available for the current Vauxhall Velox and Cresta cars differs in respect of the bell housing and cush-drive coupling, and has a five-plate clutch instead of the three-plate assembly shown. Another difference concerns the output shaft bearing layout: a Torrington needle roller thrust bearing and a steel-backed bronze bush replace the ball bearing, and the housing design is modified accordingly

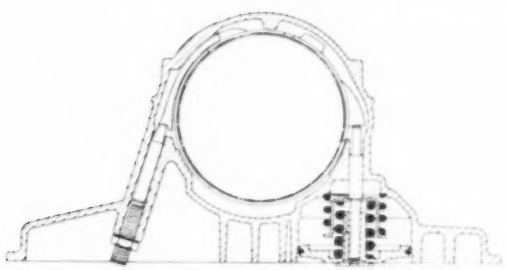


REPRODUCTION OF THE GENERAL ARRANGEMENT DRAWING OF THE HYDRA-MATIC 61-05 TRANSMISSION

comprises the driving member; dowels are used to locate the half-torus coaxially on the carrier. Both these components are light alloy diecastings, whereas the runner member—which fits between the driving member and the web of the carrier—is fabricated from steel pressings.

Both the driving and the driven members of the coupling have the usual radial vanes. The runner is splined to a solid shaft, known as the mainshaft, the leading end of which is carried in a second steel-backed bronze bush housed in a counterbore in the rear end of the input shaft. Embracing the mainshaft, to the rear of the runner, is a hollow shaft. Pressed on to splines on the leading end of this hollow shaft is the torque multiplier member of the coupling, which is interposed between the driving and driven members, and has a ring of nineteen radially disposed vanes, each of which has a curved cross section. Its function is, of course, to change the direction of the oil flow on its way from the runner back to the driving member, and thus to impart additional kinetic energy to the input. The result is an increase in the output torque, with a consequent reduction in the speed of the runner.

A second needle roller thrust bearing is fitted between the hubs of the driving member carrier and the runner, and there is a third between the other end of the runner hub and the hollow shaft on which is carried the torque multiplier unit. Immediately behind the torque multiplier element, the planet carrier for the first epicyclic train is

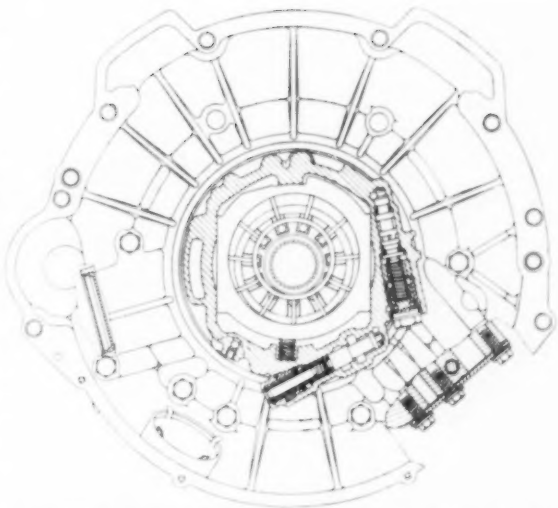


In first and second ratios, the annulus gear of the rear epicyclic train is held stationary by means of this servo operated band brake

mounted on splines on the hollow shaft. This carrier is an Armasteel casting and it provides support for each end of the three fixed spindles of the planet pinions, which run on needle roller bearings. The pinions are of the helical type, with 15 teeth, a d.p. of 18, and a helix angle of 18½ deg. There are 41 teeth on the sun wheel, which is integral with a sleeve embracing the hollow shaft on which the carrier is mounted; the annulus gear has 71 teeth. Between the sun wheel and the planet carrier is a fourth Torrington thrust bearing.

Encircling this gear train is a multi-plate friction clutch. The three steel driving plates of this have rings of friction material bonded to each side; they are externally dogged and are free to slide axially in similar dogs machined within a drum extending rearward from the driving member of the fluid coupling. In the bores of the driven plates, which are also of steel, and on the periphery of the annulus gear on which they are carried, there are similar dogs. A reaction plate for the clutch is on the annulus, and the pressure plate is at its rear. This latter plate is spring loaded towards the released position and, to engage the clutch, it is moved forward by a piston actuated by oil pressure. It is worthy of note that the Oldsmobile version of the transmission has a five-plate clutch, whereas the Vauxhall unit has three plates, because of the lower torque of the engine.

A rearward extension of the annulus gear assembly is externally splined at its end, and free to slide on these



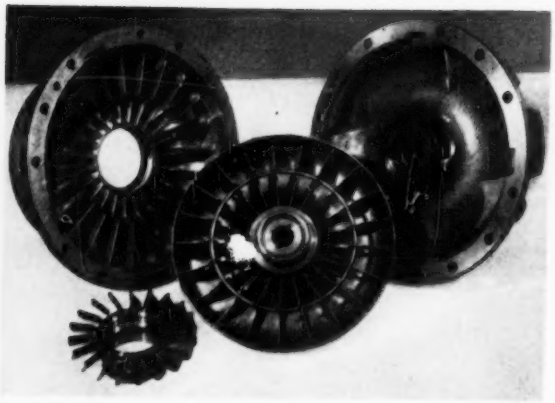
A noteworthy feature of the transmission is the eccentric vane type oil pump, in which a sliding stator member is employed to provide a variable output, in accordance with the needs of the unit. To move the slide, oil pressure is applied through passages to one end or the other of it

splines is a member having a part-conical flange. The annulus is stopped, to engage reverse, by trapping this flange between a fixed outer cone piece, of friction material, keyed to the casing, and a movable inner one of aluminium. As in the case of the multi-plate clutch, the inner cone is disengaged by a spring and engaged by hydraulic pressure applied through a piston.

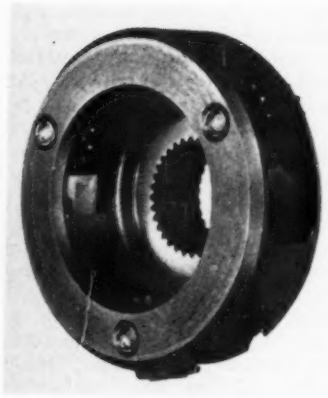
The sun wheel sleeve already mentioned is carried in a long steel-backed bronze bearing in the boss of a diaphragm type partition that fits against a shoulder in the casing. This partition is held in position by the outer member of the cone clutch, which in turn is retained by a circlip. The diaphragm carries the piston assembly for actuating the cone clutch, and also the guide pins for the inner cone member.

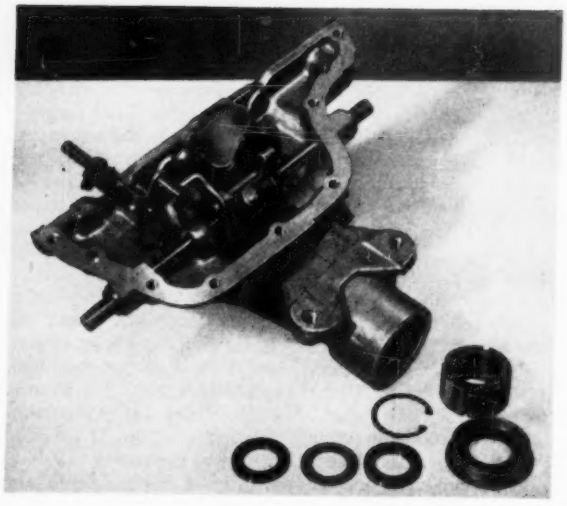
Of the major mechanical assemblies of the transmission, the remaining one is the rear epicyclic gear train. This is of similar design to the front train except that the numbers of teeth on the sun wheel, planets and annulus are respectively 33, 17 and 67. The sun wheel is a sliding fit on splines on the internal mainshaft—that which carries the runner of the fluid coupling — and the planet carrier is integral with the hollow shaft. An interesting detail is the fitting of a rubber ring into a counterbore in the rear face of the sun wheel; this ring is toothed to mesh in the splines on the shaft, and it serves as an effective anti-chatter device. Bolted and dowelled to the rear face of the carrier is the flanged end of the output shaft, which thus forms an extension of the hollow shaft. In the bored-out leading end of the output shaft is another steel-backed bronze bush into which the rear end of the mainshaft extends. There are castellations on the periphery of the flange, for engagement by the mechanically actuated pawl that, in the D position of the selector lever, locks the flange to the casing.

The drum member within which the annulus teeth are machined is mounted on splines on the rear end of the sleeve carrying the sun wheel of the front gear train. Round this drum, to lock it as necessary, is a band brake so designed as to be self-energizing in both directions of drum rotation. This characteristic is obtained by making the band in the form of an elongated tuning fork, the two arms of which are wrapped in one direction and the leg in the other; the angle of wrap in each case is little less than 360 deg. The abutments of the band are near the free ends. Those on the two arms are reacted by an adjustable pin mounted in



The front planet gear carrier, which is a steel casting; needle roller bearings are used in each of the three helical pinions

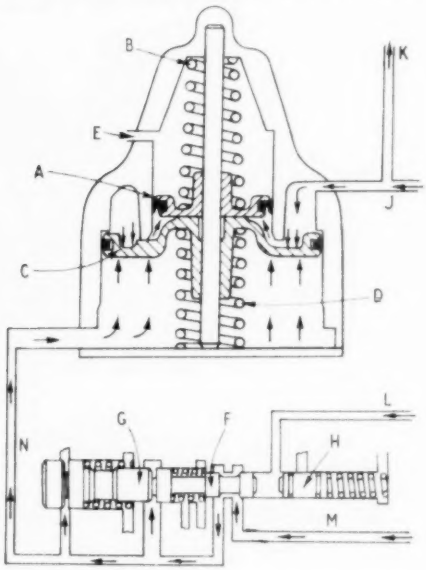


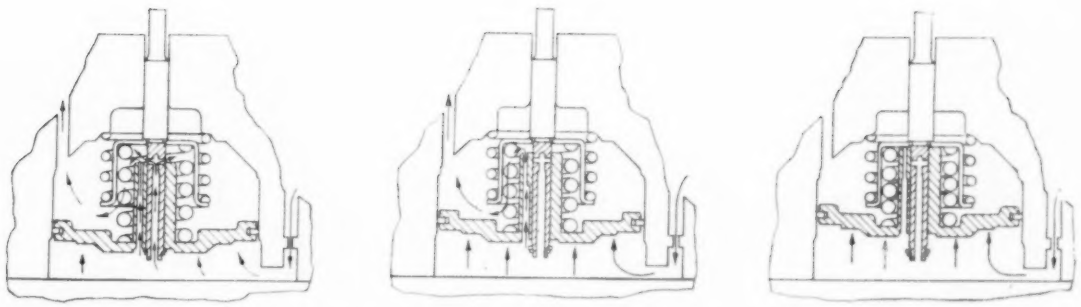


Top: The components of the fluid coupling; both the driving member and its carrier are aluminium diecastings, but the runner member is fabricated from steel, as also is the torque multiplier element. Middle: In reverse, the annulus of the front epicyclic train is held by this cone clutch. The right-hand member, which is keyed to the casing, is of friction material. Middle, right: So that it is self-energizing in both directions of rotation, the band brake for the rear annulus is made in the form of an elongated tuning fork, with its arms and leg wrapped in opposite directions. Bottom: This view of the rear assembly shows the two bearings and the actuating shaft for the manual valve

Below: Correct control of the front clutch is obtained by the use of an accumulator, of the double-piston type, shown here in section. The appropriate resistance to the downward movement of the lower piston is provided by the compensator valve illustrated diagrammatically

A *upper piston;* **B** *upper piston spring;* **C** *lower piston;* **D** *lower piston spring;* **E** *air release;* **F** *primary compensator valve;* **G** *secondary compensator valve;* **H** *compensator limit valve;* **J** *oil supply for clutch application;* **K** *feed to front clutch;* **L** *throttle valve oil pressure;* **M** *oil pressure from drive circuits;* **N** *compensator oil pressure supply*





For smooth engagement of the hand brake, its servo is arranged to function in three stages, as shown in these diagrams. In the first stage there are two paths for the fluid leakage past the piston; one of these is cut off in the second stage and both in the third, when full pressure is applied

the casing, and the other bears against the output rod of a hydraulic servo. Bonded to the inner faces of the three portions of the band are strips of friction material. As before, the brake is applied by pressure in the servo and is released by a spring. The servo unit, which is illustrated, is described at a later stage.

Immediately behind the attachment flange of the output shaft is the governor mechanism—also to be described later. In the Oldsmobile version of the transmission, the tail end of the output shaft is carried in a ball bearing, to the rear of which is a double-lip oil seal. The Vauxhall layout, on the other hand, consists of a Torrington needle roller thrust bearing and a steel-backed bronze bush, in an aluminium housing; beyond the bush is the oil seal, again of the double-lip type. Because of this difference, the extension casing of the Vauxhall unit is longer than that of the Oldsmobile equivalent, which is the one shown in the reproduction of the general arrangement drawing of the transmission.

Finally, mention should be made of a highly interesting minor feature of the mechanical specification, namely, the use at a number of points of sealing rings of unusual design. Though basically of the piston ring type, these seals are noteworthy in having interlocking ends; the resultant labyrinth effect provides a high sealing efficiency. In section, the rings are approximately square, and they are made of cast iron. In comparison with those of a ring having a conventional stepped gap, the overlapping portions of these seals are thinner—about a third of the nominal thickness of the ring—except at the very ends. Here, a tongue is formed on each by a local increase in thickness to a little more than half the nominal figure. When the tongues are interlocked, the depth of their engagement is, of course, greater than the side clearance of the ring in its groove.

Apart from their functional merit, these seals play an important part in facilitating the assembly of the unit: once the interlocking has been effected, only a small additional degree of compression is required to enter a ring in its bore. Altogether, thirteen of these rings are used. Four of them are in the governor feed and delivery system, there is one at each side of the oil pump, and there are two more between the carrier of the coupling driving member and the boss of the front wall of the casing. Two are used to seal the hub of the coupling runner, and another that of the torque multiplier; the remaining two are between the planet carrier of the front epicyclic train and the boss of the diaphragm partition mentioned on page 527.

Power flow

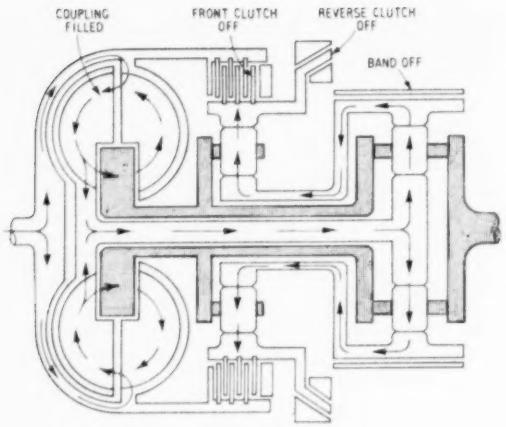
The power flow in the various operating conditions of the transmission is shown in the accompanying diagrams. In neutral, the fluid coupling is filled and all three clutches are disengaged. Consequently, both the annulus gears are spinning freely and therefore no torque is transmitted to the output shaft. The engagement of first gear involves the applying of the band brake to the annulus of the rear train. Since this annulus is held, the planet carrier of the train rotates in the same direction as the engine but at a reduced speed.

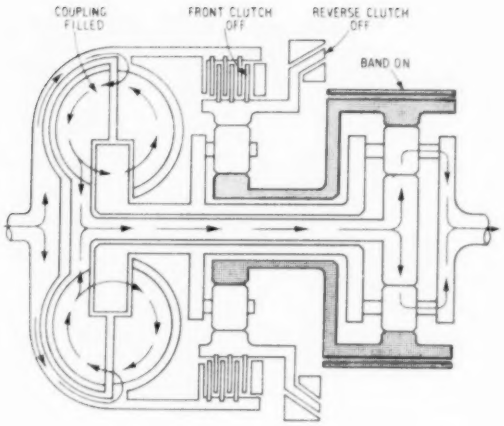
When the output shaft is stationary, or is revolving anti-clockwise, the reaction on the multiplier element is clearly at its greatest. In this condition, the runner of the coupling transmits a torque higher than that of the engine, in the ratio of 1·3 : 1, but its speed is lower, as also is that of the sun wheel of the rear epicyclic train. The overall reduction is then 3·64 : 1, composed of the 3·03 : 1 of the train, multiplied by the 1·3 : 1 of the speed reduction through the coupling, less the 0·3 torque reaction effect on the multiplier element, since this is in the opposite direction to that of rotation. However, as the forward speed of the output shaft increases, that of the sun wheel and runner shaft rises also, and so the reaction on the multiplier is lessened. Consequently, the overall reduction is progressively changed to 3·03 : 1.

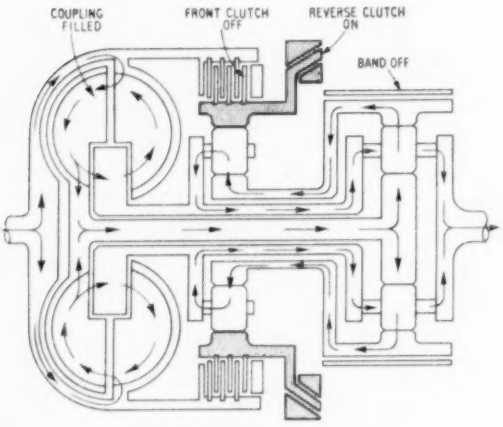
In second gear, the band on the rear train annulus remains engaged, but the multi-plate front clutch is also applied and the coupling is emptied. Because the sun wheel of the front train—which, as explained, is directly connected to the band drum—is stationary, the carrier of this train revolves clockwise at a lower speed than the annulus, which is now clutched to the driving member of the coupling. The output shaft also revolves at this lower speed, since it is locked to both carriers. It will be evident that, owing to the effect of the rear train, the runner of the empty coupling rotates clockwise faster than does the driving member. All the reduction in this gear comes from the front train, which has a ratio of 1·58 : 1.

On engagement of the direct third gear, the coupling is filled again, and the front clutch remains engaged, but the band brake is released. In this condition, both gear trains rotate as a unit. Any tendency for the output shaft to revolve more slowly than the driving member of the coupling results in a speeding-up tendency of the rear sun gear, and so of the runner. Since this acceleration would cause work to be done on the fluid, it is resisted by the coupling. Hence, the slip is small and the efficiency high.

For reverse, the coupling is filled, the cone clutch is engaged and the other two clutches are free. As in first gear, the torque multiplication is effective and is applied through the coupling to the sun gear of the rear train. The rear annulus, therefore, revolves in an anti-clockwise direction, as also does the front sun wheel connected to it. Because the front annulus is held by the reverse clutch, the front carrier, rear carrier and output shaft, too, revolve anti-clockwise, but at a lower speed than the sun wheel. The overall reduction is 3·57 : 1, comprising 2·52 : 1 through







These five diagrams show the power flow through the transmission; the shaded portions are stationary. Left to right, the diagrams in the top row apply to neutral, first, second—in which the coupling is empty—and top gears; the final one, above, is for reverse gear

the gear trains, multiplied by the 1·3 : 1 due to the torque multiplication, plus the 0·3 of the multiplier reaction, which is then in the same direction as the rotation of the output shaft.

Accumulator and band servo

Smooth engagement of the front clutch in various conditions of load is ensured by the incorporation of a hydraulic accumulator and a compensator in its actuating circuit. The purpose of these components is to apply the clutch smoothly and relatively slowly at small throttle openings, but quickly and firmly when the throttle opening is large. Inside the pressed steel body of the accumulator are two cylinders, each containing a piston: these two pistons are free to slide on a guide rod and are spring loaded towards each other. The diameter of the lower cylinder is greater than that of the upper one.

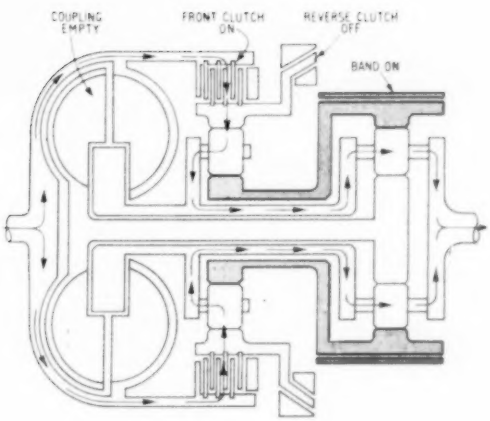
A tapping from the oil feed line for clutch application leads to a space between the two pistons in the accumulator. When the oil pressure is applied to the line, the clutch piston starts to move against its spring and, as the resistance increases, the oil pressure in the accumulator causes the pistons to separate; the flow to the clutch piston is consequently slowed. As the resistance of the accumulator springs builds up, increasing pressure is applied to the clutch piston until, when the accumulator pistons reach the limit of their stroke, the full hydraulic line pressure is applied to the clutch, thereby ensuring that its engagement is complete.

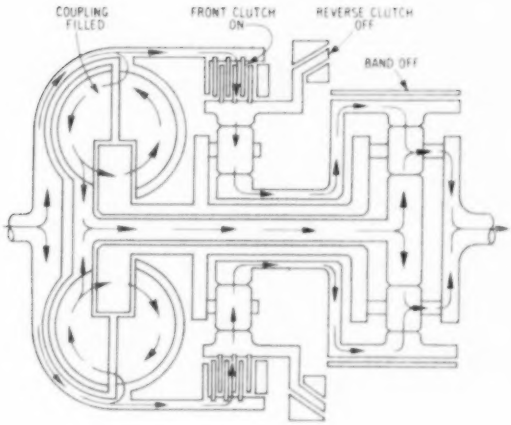
This basic behaviour of the accumulator is modified by the compensator, the function of which is to make the accumulator sensitive to variations in engine load. In the compensator there are two spool type, spring-loaded valves in tandem, known respectively as the primary and secondary compensators. Oil pressure is transmitted to the compensator by the throttle valve, which will be described in Part 2 of this article, and so is proportional to the engine load. This pressure is applied to one end of the primary compensator valve and lifts it off its seat, thereby permitting oil from the drive line to be admitted to the underside of the lower piston of the accumulator. The pressure of this oil is clearly proportional to the movement of the primary valve, and so to the engine load.

Until the pressure of the delivery from the throttle valve rises above a certain value, the secondary compensator valve —which is subjected to this pressure—does not move against its spring. Once the pressure is sufficient to overcome the resistance of the spring, the secondary valve moves with the primary component. As a result, the compensation is regulated to suit the requirements of the system. Further modulation of the compensator output pressure is effected by the compensator limit valve in the same housing. It will be evident from the foregoing that the downward movement of the accumulator piston is opposed by the oil pressure from the compensator. Consequently, the greater the compensator pressure the greater is the pressure on the clutch piston during engagement.

The hydraulic servo that applies the band brake of the rear epicyclic train comprises a cylinder containing a piston, which is free to slide on a rod and is spring loaded downward. This rod, in turn, is free to slide axially in a hole through the upper end of the servo housing; on its lower end are a washer and circlip forming a limit stop for the piston, the upper stop being a shoulder on the rod. Its top end projects through the servo housing, to bear on the actuating abutment of the band, as already mentioned. The spring's upper abutment, which is an inverted cup-shape pressing, is surrounded by a second and lighter spring, called the release spring, one end of which seats on a flange around the lower edge of the cup and the other end bears against the top of the servo cylinder.

As will be apparent from the power flow diagrams, the band is applied to engage first gear from neutral, or second gear from third. For smooth engagement, the servo is designed to function in three stages. Oil is fed to the underside of the piston, and in the first stage there are two leakage paths for it to the upper side : one of these is in the piston guide rod, and consists of an axial and a diametral drilling,





while the other is a vertical, drilled hole in the boss of the piston. In the first operating stage, because of the leakage, pressure builds up relatively slowly under the piston which, with its spring, cup and rod, moves upward against the resistance of the release spring, thereby taking up the clearance between the band and the drum of the annulus.

When the band begins to tighten on the drum, and the upward travel of the rod is resisted, the piston continues its movement on the rod itself, against the thrust of the main spring. The boss of the piston then covers the transverse drilling of the first leakage path, so the pressure build-up in the cylinder is accelerated. On further upward travel of the piston, its boss butts against the spring retaining cup, and thus seals the second leakage path. The full hydraulic pressure is then transmitted directly through the rod to the brake, thus ensuring that the annulus is firmly held.

Alcan Industries Expansion

A FOUR-YEAR expansion programme, which is expected to cost about £8,000,000, is being carried out by Alcan Industries Ltd, formerly Northern Aluminium Co. Ltd, at their Rogerstone factory, near Monmouth. The purpose of the scheme is to raise the output of the continuous strip mill from 50,000 to 75,000 tons a year, to cope with the increasing demand for plate, sheet and foil made from aluminium and its alloys. In the planning of this expansion, provision has been made for the likelihood of subsequent further expansion to an ultimate capacity of 175,000 tons a year.

Recently the programme reached its half-way stage, when some of the new equipment, including a 144 in wide hot mill, was put into operation. This mill has been installed at the head of the line—which is ½ mile in length—and can be used either on its own or as part of the line. The largest mill previously employed had a width of 96 in, and the maximum width of plate that it could produce was 6 ft. Now that the larger mill is in service, plates of well over 10 ft wide can be produced. These can be as long as 50 ft and of a thickness down to ¼ in, and will be of considerable value in many industries.

Other changes made at the plant include enlargement of the remelting furnace plant for the addition of alloying elements to the imported pig aluminium that forms a part of the mill's raw material. More pre-heating furnaces have been installed in the hot line, which has also been improved by the incorporation of new equipment for shearing, edge trimming and coiling. The cold rolling facilities too, have been augmented, notably in respect of the annealing capacity available.

Photogrammetry

FOR many years photogrammetry has been used for geographical, military and other survey work. It can be defined as the science and art of making precise measurements from photographs. Recently, and particularly within the last decade, the potential of this method of scientific measurement has become apparent in other fields, including various branches of engineering.

Briefly, the value of photogrammetry, in its most general concept, is that it provides a means of making extremely precise measurements of a phenomena in three dimensions. Moreover, moving as well as static phenomena can be measured. O.M.I. Instruments (Great Britain) Ltd, of Maxwell House, Arundel Street, London, W.C.2, are marketing in Great Britain the Nistri Photostereograph model BETA/2 equipment; this company claims that with this equipment, measurements can be taken from stereoscopic photographs of, for example, the stylist's prototype model of a vehicle body and transferred to layout drawings. It is said that considerable savings in respect of time can be obtained by the use of this method at the design stage.

TECHNICAL BOOKS FOR

Christmas

For those who wish to give technical or semi-technical books as Christmas presents, the following can be obtained through any bookseller or directly from Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Rates by post are in brackets.

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FILMING WITH 16 mm, 25s (25s 11d)

P.S.V. Heating and Ventilation

(CONTINUED FROM PAGE 419)

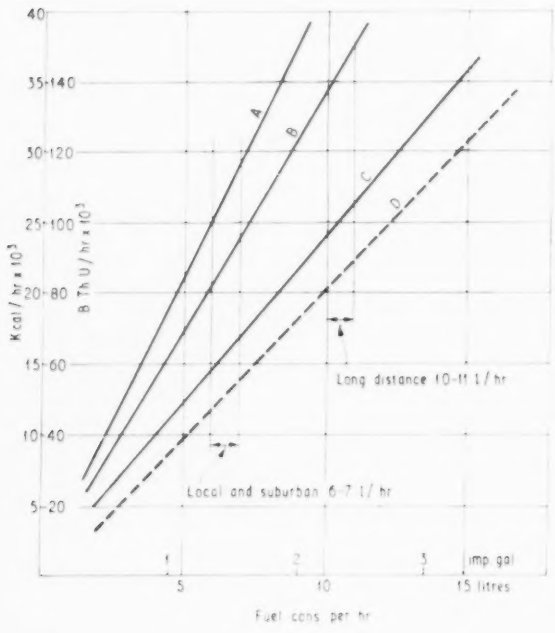
Part II: Sources of Heat, Bus Heating Systems, and Overnight Parking Requirements

HUGO BJÖRCK

THE most economical method of heating buses is undoubtedly to use the otherwise wasted heat from the engine. For reasons that need not be elaborated upon here, the only reasonably suitable source is the heat lost to the cooling systems of water-cooled engines. As for air-cooled engines, at present there is no such simple method of utilizing the waste heat, and this is a disadvantage.

Thermal efficiency varies with the type of engine, and therefore so also do the heat losses for any given amount of useful work. In the following discussion, comparisons will be made, from the point of view of heat lost to the cooling water, between petrol engines and two different types of diesel engine, that is, with a precombustion chamber and with direct injection. All the engines are assumed to be of comparable size, 125 to 150 b.h.p, and installed in an 11-metre long bus, as in Part I of this article.

Fig. 4. These curves are an approximate indication of the heat loss to the cooling water in different types of petrol and diesel engine **A** *petrol;* **B** *diesel, with pre-combustion chamber;* **C** *diesel, direct injection;* **D** *diesel, direct injection, net at 0 deg C*



The heating requirements have been calculated per hour, so, if possible, the heat available should also be estimated in terms of units per hour. In a bus, the full power output of the engine is used for only very short periods. It is estimated that the mean load on the engine during actual driving in suburban traffic is about 40 per cent of the maximum, and the average speed approximately 1,400 r.p.m. However, stationary periods at stops and termini tend further to reduce the supply of heat available, so these figures cannot be used for calculating the overall heat losses. The author has, therefore, arrived at the conclusion that it is best to estimate the amount of heat lost per hour on the basis of the fuel consumed per hour. Transport company statistics generally give fuel consumption in l/km, or mile/gal. So, if the average speed is known, the consumption per hour is easily arrived at. The hourly consumption for a diesel bus, with a direct injection engine, in city and suburban traffic in Sweden is in the region of 6 to 7 l/hr (1·3 to 1·5 gal/hr). In long-distance traffic the fuel consumption per km is lower, but the speed is so much higher that the fuel consumption per hour becomes much greater, that is, approximately 10 to 11 l/hr (2·2 to 2·4 gal/hr).

Calculations of the approximate amount of heat available for the interior can then be made by assuming:

(a) heat lost per hour to the engine's cooling water is proportional to the fuel consumption per hour
(b) the efficiency and losses, expressed as a percentage, for each type of engine are always the same, regardless of the traffic conditions.

Experience shows that for estimations based on consumptions of the order of 6 l/hr for a diesel engine with direct injection, the equivalent engine with precombustion chambers yields a consumption of about 7 l/hr, and a petrol engine about 10·3 l/hr. The heat loss varies greatly, as between the three types, and is approximately as in Table 3. Losses to the engine coolant are shown in Fig. 4.

It must be remembered that the figures given in Table 3 are gross values, and certain unavoidable losses in the engine and components, such as the radiator and pipes, must be subtracted from them. For the purpose of estimating the actual heat quantities available for the interior in each case, it can be assumed that these losses are practically the same for all types of engine. This makes the diesel engine with direct injection even more unfavourable as a source of heat for the interior of the vehicle than is indicated in

Table 3—TYPICAL VALUES OF THE HEAT LOSSES FOR PETROL ENGINES AND TWO TYPES OF DIESEL ENGINE

	Petrol engine		Diesel engine, precombustion chamber		Diesel engine, direct injection	
	per cent	kcal/hr	per cent	kcal/hr	per cent	kcal/hr
Useful work	24	17,800	30	17,800	35	17,800
Loss to cooling water	33	24,400	34	20,300	28	14,300
Loss to exhaust gases	36	26,600	29	17,200	30	15,300
Loss by radiation	7	5,200	7	4,200	7	3,600
Heat supplied	—	74,000	—	59,500	—	51,000

Table 4—HEAT AVAILABLE ON LOCAL AND LONG-DISTANCE OPERATION

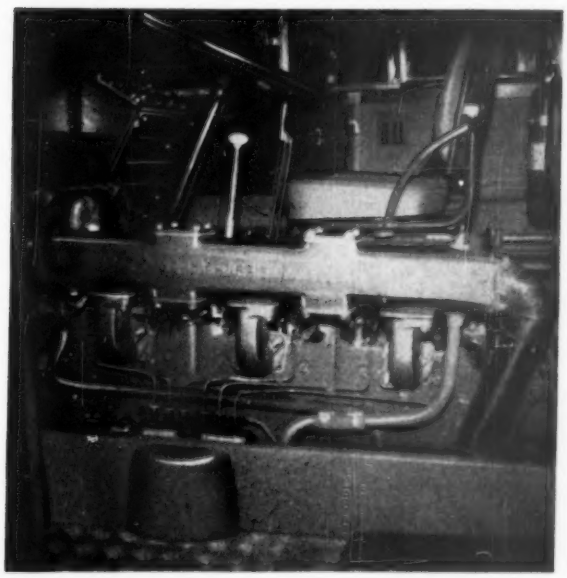
Engine type	Local traffic kcal hr	Long-distance traffic kcal hr
Petrol	21,500	37,000
Diesel, precombustion chamber	17,500	29,000
Diesel, direct injection	11,500	19,800

Table 3. For comparison, Table 4 contains values of heat available for local and long-distance traffic. In both cases, the unavoidable losses already mentioned are deducted, and for long-distance traffic the fuel consumption is assumed to be 10 l/hr.

The values given in Table 4 apply when the radiator and engine are conventionally placed, at the front of the vehicle, and at an outdoor temperature of 0 deg C (32 deg F). The unavoidable losses previously mentioned will be greater at lower outdoor temperatures: for example, at − 20 deg C there will probably be a further reduction of approximately 2,000 kcal/hr for this type of installation.

From this survey, it can be seen that the heat quantities available from the cooling water of diesel engines with direct injection are small, especially under local traffic conditions.

Fig. 5. A water cooled exhaust manifold, of marine type, connected in parallel with the cylinder block cooling system, furnishes an additional heat quantity of about 3,000 kcal/hr (12,000 B.Th.U/hr)



Engines with precombustion chambers deliver 50 per cent more heat to the cooling water, and this explains why, in countries with cold climates, changing from this type of engine to the direct injection type has created difficulty in respect of heating buses.

However, the conditions are in any case mitigated by the fact that each passenger helps to heat the bus by contributing approximately 100 kcal/hr (400 B.Th.U/hr). A bus containing 25 passengers will thus receive an additional heat quantity of 2,500 kcal/hr (10,000 B.Th.U/hr).

A simple way of obtaining additional heat is to install a water-cooled exhaust manifold of marine type, Fig. 5, and to connect it with the cooling system, in parallel with the cylinder block. In this way, under local traffic conditions of

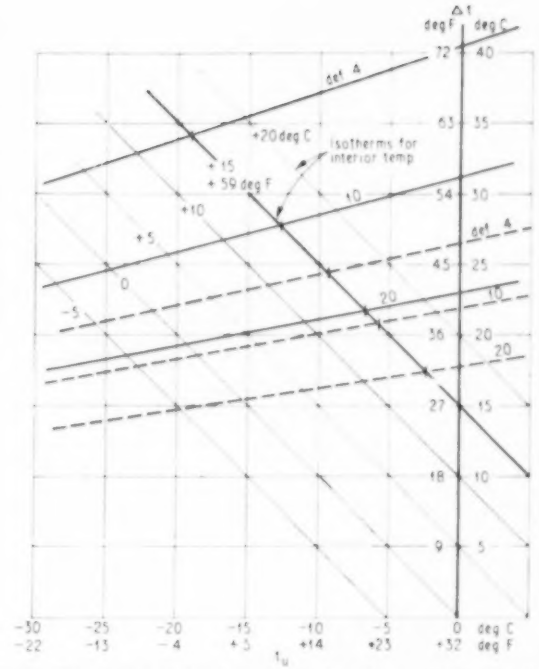


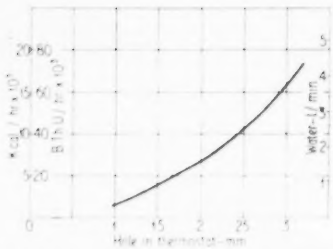
Fig. 6. This nomograph has been prepared on the assumption that the heat available for the interior of the vehicle is 12,000 kcal/hr (48,000 B.Th.U/hr) at 0 deg C, and 10,000 kcal/hr (40,000 B.Th.U/hr) at − 20 deg C, and therefore the lines for the attainable temperature rise Δt are sloping; the figures on these lines are those indicating the numbers of complete changes of air that are effected per hour. Interior temperatures at different ambient temperatures can be found most easily by means of the isotherms for the interior temperature

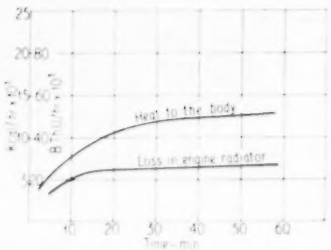
operation, additional heat of the order of 3,000 kcal/hr will be supplied to the cooling water of diesel engines with direct injection.

The best way of observing how the temperature conditions vary in buses with and without insulated bodies, and with different degrees of ventilation, is by means of a nomographic chart containing isotherms for interior temperatures. A chart of this kind is shown in Fig. 6. In this illustration, it can be seen that, with 20 changes of air per hour, the line for an insulated body cuts the isotherm +15 deg C at $t_u = -6{\cdot}5$ deg C. This means that at lower ambient temperatures the ventilation must be decreased in order to maintain an interior temperature of +15 deg C. Similarly, it can be seen that the line representing conditions with 10 changes of air per hour cuts the isotherm +15 deg C at − 12 deg C. If this air change frequency is retained at lower ambient temperatures, the interior temperatures will drop and will be +6 deg C at −20 deg C. However, if the ventilating air is limited to that supplied by the defroster fan, an interior temperature of +15 deg C can be maintained down to an ambient temperature of − 19 deg C.

In buses with uninsulated bodies, the temperatures will be unsatisfactorily low: with a supply of air corresponding to that provided by the defroster unit, the interior temperature will be only +2 deg C at − 20 deg C, or approximately 12 deg C lower than in insulated buses.

These facts make it clear that the best possible insulation is required for buses operated in cold climates. Good ventilation, however, must not be bought at a price of lower interior temperatures, and even when the insulation is satisfactory, the desirable standard of 20 changes of air must be reconsidered. At low outdoor temperatures, this high frequency of air change is not possible without installing





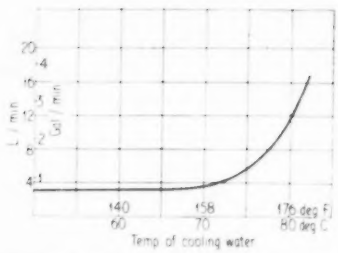


Fig. 7, left: Effect of thermostat by-pass hole on the quantity of heat passed to the engine radiator, on the basis of a water temperature of 70 deg C. Most of this heat can be lost if the radiator is not carefully shielded. Fig. 8, centre: Heat to the interior of the vehicle and to the engine radiator during a test run under controlled conditions. Despite the fact that the radiator was well shielded, the loss through it was high. During the test, the fuel consumption was 8·4 l/hr (1·8 gal/hr) and the total heat loss to the cooling water is estimated to have been 20,000 kcal/hr (80,000 B.Th.U/hr) at an ambient temperature of −3 deg C. Fig. 9, right: Quantity of water passing through a thermostat with a 2·7 mm diameter by-pass hole. In an engine operating at 1,400 r.p.m. the thermostat may begin to open at about 70 deg C although its opening temperature is quoted as 85 deg C

a heater unit operating independently of the engine. Such a unit, however, will be expensive not only in respect of first cost, but also in operating costs.

To obtain sufficient heat from the cooling water of a diesel engine with direct injection, the losses from the radiator and other parts must be kept to a minimum. The following example will show how critical are these losses.

A bus radiator is designed to dispose of approximately 60,000 kcal/hr (240,000 B.Th.U/hr) at an ambient temperature of +30 deg C (86 deg F). The cooling effect at −20 deg C is nearly doubled relative to that at 30 deg C, and even a negligible quantity of air passing through the radiator causes the loss of considerable quantities of heat. Unless anti-freeze—which can be costly and troublesome for companies with a great many vehicles—is used, a definite degree of circulation must be constantly maintained in the radiator to prevent its freezing. The most dangerous period is after starting when the engine is cold, and since the circulation must be adequate for this condition, it will be unnecessarily high when the engine has reached its normal running temperature.

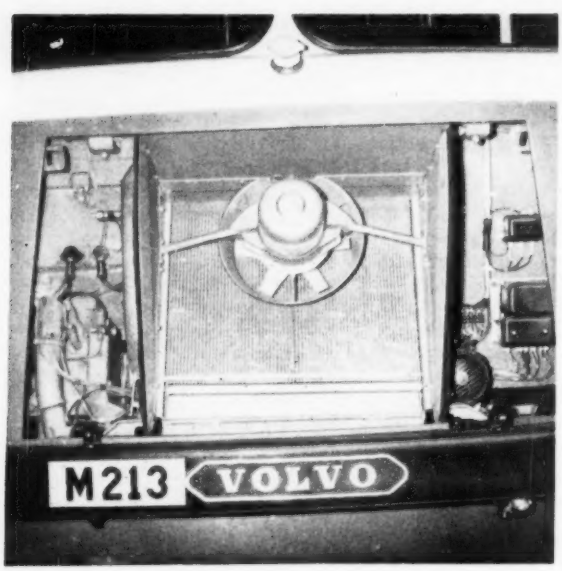
Probably all bus engines are today equipped with a thermostat to stop completely, or to limit, the flow of cooling water to the radiator when the temperature of the water is below a certain value; a thermostat is an absolutely essential requirement if a heater operated by the coolant is to be used. To guarantee the necessary minimum circulation in the radiator, for cold starting, the thermostat must have a small by-pass or leakage hole which, experience has shown, must be 2·5 to 3·0 mm diameter for conditions in Sweden, Fig. 7. This hole ensures a water circulation of approximately 3 l/min (0·65 gal/min), and at a cooling water temperature of 70 deg C, a heat quantity of 12,600 kcal/hr (50,000 B.Th.U/hr) is passed to the radiator. All this heat can easily be lost in a badly shielded radiator. Even a radiator that, in the usual sense, is well shielded can lose half this heat quantity, Fig. 8, and even that is too much for a good standard of interior heating to be obtained.

In this connection, it should also be mentioned that a thermostat with a rated temperature of 85 deg C (185 deg F) begins to open at a temperature of as low as 70 deg C (158 deg F), Fig. 9. The amount of water passing through the radiator—and with it the heat losses—then increases to such a degree that when the ambient temperature is low the engine temperature does not rise above 70 deg C. Thus, with thermostats arranged as at present, the radiating surfaces of a heating system should be dimensioned to suit an incoming water temperature of 70 deg C, Fig. 10. If the heating system is designed for a water temperature of 85 deg C, as is often done, the heat-radiating surfaces are too small, since this higher temperature may not be attained in practice.

A good way to reduce losses in the radiator in winter is to disconnect the fan, and this rarely presents any problems with regard to cooling when the engine and radiator is at the front of the vehicle. Some form of thermostatically governed fan operation, mechanical, hydraulic or electric, is the best solution, as it leads to gains in respect of engine power available and economy of fuel consumption at all times of the year. It is difficult to understand why this matter has not been given more attention than hitherto, since there is so much to be gained relatively simply.

The problem of obtaining from the cooling water sufficient heat for the interior of the vehicle appears to be more difficult with underfloor engines. This is, no doubt, due to the fact that the engine is freely surrounded by cold air, and therefore certain losses occur which have no equivalent in the case of an engine at the front. Usually, the radiator also is under the floor, and this seems to create even greater difficulty, for this type of radiator, with its very powerful fan, cannot easily be shielded adequately. It is, therefore, the opinion of the author that, even in the case of an underfloor engine, the placing of the radiator at the conventional height at the front of the vehicle is definitely to be preferred in cold climates, Figs. 11 and 12; an additional advantage of this layout is that the driver, and components such as brake valve and steering-gear, at the front, will automatically receive some benefit from the warmth of the

Fig. 11. Details of the fan installation in the bus illustrated opposite



radiator. Yet another advantage is that a conventionally placed radiator can serve as an expansion vessel for the heating system, and this layout also appears to constitute a remedy for other troubles that have arisen in connection with cooling an underfloor engine, and experience has shown that for most traffic conditions a fan is not necessary.

If the temperature of the engine cooling water does not rise above 50 to 60 deg C, and it is therefore difficult to obtain sufficient heat for the interior of the vehicle, a very simple experiment will show whether the trouble is due to losses in the radiator. First, disconnect the radiator entirely and, preferably, also the fan, since this considerably increases the heat losses from the engine itself. Next, connect the engine cooling system directly to the heating circuit. A test run is then made with the average load, speed and waiting time at stops the same as under normal traffic conditions. If the temperature of the engine then rises above normal, this proves that there is more heat coming from the cooling water of the engine than that which corresponds to the output of the heating system. The only problem will then be to reduce the losses sufficiently to make the necessary heat available for the interior of the vehicle.

Arrangement of a bus heating system

The heat from the cooling water can be conveyed to the interior of the bus by two systems differing in principle:

(1) *Direct heating*, whereby the cooling water is led through metal radiators or through finned pipes

(2) *Indirect heating*, whereby air, either fresh or recirculated, is blown, by means of a fan, through a heater unit to the interior of the bus.

A heater unit operating on the second of these two principles is required for ventilation purposes and also for use as a defroster. In the latter case, however, the fan must be adequate to impart to the air the required velocity.

Some buses are heated by indirect means only, but this necessitates some form of automatic regulation to prevent cold air from being blown in during the engine warm-up period or while waiting at a terminus. This is why buses in Sweden often employ a mixed system which, from the point of view of regulation, is more foolproof in normal operation.

In the case of the 11-metre long bus used as an example for earlier calculations, a suitable balance between direct and indirect heating can be obtained as follows. The heat emission has been calculated for an incoming water temperature of 70 deg C and on the assumption that $t_i = +15$ deg C and $t_u = -20$ deg C.

	Heat emission kcal/hr
Hot-water radiators, approximately 10 m^2	4,500
Defroster, average fresh air 150 m^3/hr	3,000
Ventilator for fresh air, only, 300 m^3/hr	5,000

The defroster is usually designed with three set positions, and the ventilator for two.

From these figures, it can be seen that the total heat consumption will be 12,500 kcal/hr (50,000 B.Th.U/hr), and this quantity is almost always available. The hot-water radiators have a great advantage in that they serve as heat accumulators during the long waits at the terminus. When the engine is stopped, the temperature inside the bus drops slowly, and after 15 minutes, the heat given off by the radiators is still about half of that normally emitted.

Fig. 12. Swedish city-bus with an underfloor engine and a cooling system specially arranged by Malmö Stads Spårvägar. The radiator is in the conventional, high position at the front, and the installation includes a thermostatically controlled electric fan driven by a motor rated at 200 W

Only 10 changes of air are possible with the heating system described above. If 20 changes are wanted, one more heater unit must be installed, and it must be arranged to change from fresh air to recirculated air when necessary. With an all fresh air system, the total heat consumption will be 17,500 kcal/hr (70,000 B.Th.U/hr), and with partly recirculated air, 15,500 kcal/hr (62,000 B.Th.U/hr). Since these quantities are not always available, regulating problems arise, and for this reason, the author prefers the simpler system, with 10 changes of air. Most passengers prefer warmth to ventilation and the lower air change frequency therefore presents no major problem.

Outside garaging

For 10 years, it has been a practice in Sweden to keep buses out of doors during the night, with devices for heating the engine and the interior of the bus during cold weather. This entails the supply of heat to the engine cooling system,

and the circulation of the water in the engine and through the heating conduits. It is easiest, when buses are kept out at night, to warm their interiors with hot water radiators; this is an important reason why radiators are used by several Swedish transport companies to supply heat to meet the requirements corresponding approximately to the transmission loss incurred by a stationary vehicle under normal conditions during the winter months.

The heat needed per bus is over, rather than under, 5,000 kcal/hr (20,000 B.Th.U/hr) at minimum outdoor temperatures, and it can be supplied by any of the following systems during outdoor parking.

(1) Blowing low-pressure steam through an injector into the heating system, to provide both heat and circulation
(2) Connecting the engine and heating system to a circulating supply of hot water, the temperature of which is regulated in accordance with the prevailing outdoor temperature
(3) By means of a mains-connected electric heater unit, comprising both a heater cartridge of 4 to 6 kW and a circulation pump. A built-in thermostat regulates the temperature of the water in the system
(4) By hot air from, for example, an oil-heated thermobloc. The air is supplied partly to the inside of the bus and partly under the engine.

All these heating systems are in use in Sweden. Electrical heating is, perhaps, most suitable for a small number of vehicles. However, the power requirement is very high if there are a large number of vehicles. Several new installations of the second of the four types listed have been made, and there is no doubt that this system is the best in respect of facility of regulation in accordance with the outdoor temperature and thus obtaining most economically the required results.

The installations in Sweden have given good results, and they have been the object of much study by groups from many countries including Germany, Holland, Denmark and Finland. Despite outdoor temperatures of as low as −25 deg C, the bus engines are easier to start than if the vehicles had been kept indoors, and the interiors of the buses can be kept at an acceptable temperature.

It is not possible here to deal in more detail with these installations. However, it should perhaps be mentioned that even buses that obtain their heating from fan type units can be kept out of doors with their engines and heating systems connected to circulating hot water. Heating the inside can in this case be arranged by having the heater unit fans, which are connected to an external source of current, started about 1 to 1½ hours before the bus goes into operation in the morning. A central time relay switch is generally used for this purpose.

Opinions in Sweden are divided with regard to the economical advantages of outdoor garaging. However, the number of installations has steadily increased, and there do not appear to be any technical drawbacks in the operation of these systems, even during the coldest of winter weather.

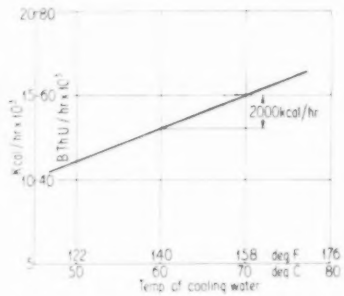


Fig. 10. Variation of output with water temperature of a heating system designed to give 15,000 kcal/hr at 70 deg C. At 60 deg C the output is about 2,000 kcal/hr lower than this

Summary

With reservations concerning the approximations and simplifications that have been necessary, the author has endeavoured to analyse, by calculation, the requirements and possibilities of heating and ventilating diesel buses with direct injection engines. The analysis shows that although the quantity of heat lost to the cooling water for such engines is relatively small, with due care to details in respect of avoidance of loss of efficiency, it should be sufficient to provide an acceptable standard of heating and ventilation. To achieve this standard, however, it is necessary not only to have very good body insulation, but also to obviate heat losses wherever they occur. Thermostatically controlled fan operation also seems desirable if not, in certain cases, essential. With underfloor engines, the radiator should be conventionally placed at the front of the vehicle. A water-cooled exhaust manifold can also be a good source of heat.

The ability to offer passengers satisfactory heating and ventilation in cold weather plays a fairly important role in

Fig. 13. This illustration shows the open-air parking arrangements of the Transport Department of the city of Boras, Sweden. The buses are heated by hot water mains

competition with private cars. Work put into improvements in these respects can pay good dividends in the form of increased goodwill and revenue. However, many complex problems have to be overcome. Trial and error and guesswork methods can, and must, be replaced by designs based on facts and calculation. This practice must be adopted on a scale larger than hitherto, for dealing with the equipment of buses with heating and ventilating systems suitable for different climates, including tropical as well as cold ones.

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A 3,000 TON TRANSFER PRESS

Schuler 340 h.p, Eight-station, Fully Automatic Press for the Production of Relatively Large and Heavy Components at Rates Up to 1,000 per Hour

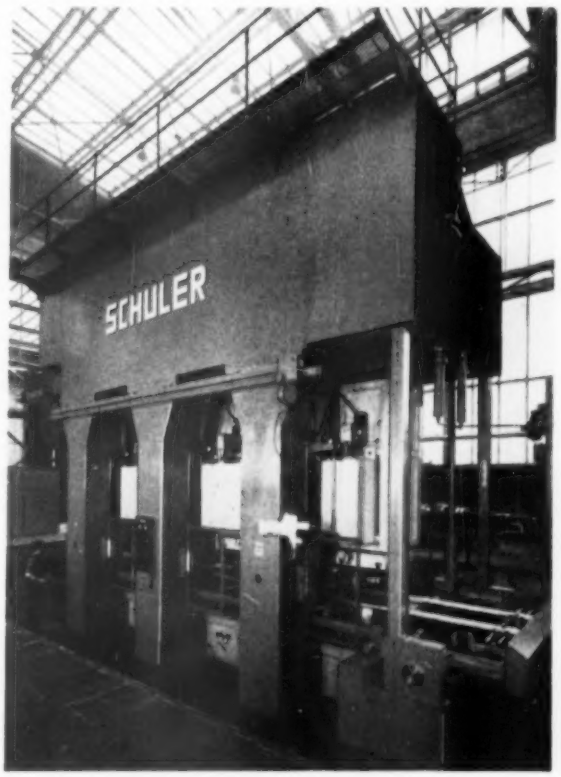
TRANSFER presses are usually employed for the production, at high output rates, of precision components requiring a series of blanking, piercing, forming, and drawing operations. Their application had, until recently, been confined to small- and medium-size work in material of relatively light gauge. By the introduction of the huge press shown on this page, the German firm, L. Schuler AG, of Goeppingen, has advanced the technique of transfer pressing to the production of large, heavy-gauge workpieces. Using the well-proved Schuler basic design, it has eight stations and is capable of operating on workpieces up to 500 mm diameter and up to about 15½ lb in weight, such as hitherto were produced on a line of individual presses. The ram stroke is 350 mm and the pitch of the tool stations is 750 mm. Maximum pressure exerted is 3,000 tons and the total weight of the machine and its auxiliary equipment is 400 tons.

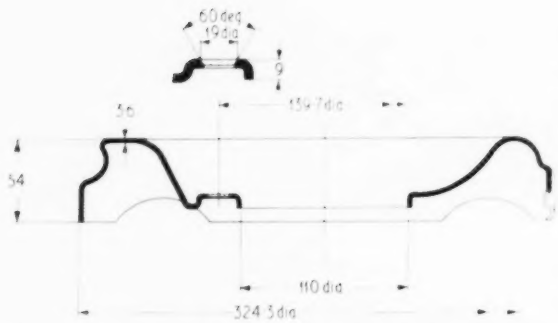
Specifically, it was designed for the automobile industry and its first duty will be to produce car wheel bodies, as illustrated on the following page and detailed on the sectional drawing. It will be noted that the thickness of the sheet material is 3·6 mm (0·1417 in) equivalent to 9 S.W.G. In this instance the press will stroke at the rate of 15/min, giving a throughput of 900 bodies/hr. Tooling for this component has been supplied with the press. Although the weight of the tool set is approximately five tons, special handling equipment is incorporated in order that one set can be taken out with ease and rapidly replaced with another set for a different component.

The practicability of building a transfer press of this size was possible due to the advantageous load characteristics of the established Schuler design. This patented design eliminates bending stresses in the headpiece or crown as there is virtually no structural load on this part. The press frame is built up of a number of parts of welded construction and the table, ram columns, and anchor columns are all of generous proportions offering a high moment of resistance. Unconventionally, the ram is driven by three pitmans from eccentrics taking their bearings within the uprights and between the anchor columns. Consequently, the entire working pressure is taken up by the anchor columns as a tensile load.

This feature, in conjunction with the robust construction of the table and the ram, gives the machine the great rigidity which is essential for the manufacture of components of large area and in relatively thick material. A further advantage of the design is that precision sizing and embossing operations can be performed within the uprights, although the loads for such operations vary according to tolerance in the sheet thickness, without ill effect on the other tool stations. Since there is no bending stress it follows there will be no bending strain at this stage.

Not only the machine frame but the entire drive is designed so that, even at maximum loading, deflection will be held to a minimum. The press is driven from the motor by way of the flywheel through a massive single-plate clutch, furnished with an instant stop action during the stroke. So generously proportioned is the clutch that it is claimed that even when operated at maximum frequency there is virtually no wear. In order to provide good control of the press the response time of the clutch has been kept very low. For





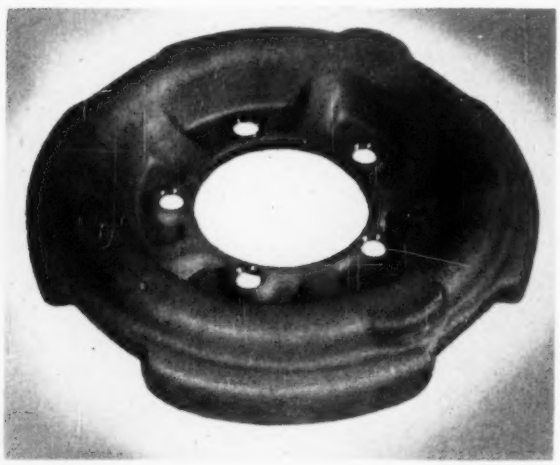
Section of the component being produced. The bolt holes are chamfer-embossed on the transfer press

greater sensitivity, when tool setting, for example, an extra low speed is provided.

A total of twelve guides—four in each upright—provided for the ram are each adjustable for setting by long wedges in order to give rigid support against transverse loading. Six pneumatic ejectors are built into the ram. Setting of the carriers for the upper tools is facilitated by clock adjusters and indicating scales. In the press table, pneumatic drawing cushions are fitted at six of the tool stations. The pressure on the blank holder for each cushion can be individually adjusted by means of hand wheels on the table and is indicated on attached pressure gauges.

The machine is equipped with a fully automatic, multiple-magazine, blank-feeding system. Blanks are taken one at a time from the stack in a magazine and placed in the gripper feed of the press. A safety device prevents more than one blank, or a blank of incorrect thickness, from being fed forward. When a magazine has been emptied it is

Car wheel body as it leaves the press. Overall diameter is 324·3 mm and the weight 7·48 lb



automatically exchanged for a full one without stopping the press or even incurring a single idle stroke. Thus, so long as the magazines—there are three in all—are loaded with blanks, operation can be continued without interruption and there is no loss of production.

Transfer of the workpiece within the press is arranged on the familier Schuler system. The mechanism for the gripper movement ensures that the workpiece is picked up and released, after transfer to the next station, smoothly and precisely. At the end of a transfer movement the workpiece, therefore, has experienced no adventitious movement and is orientated precisely as before. Accordingly, a workpiece that, by reason of its shape, does not seat steadily, can be fed smoothly even at high speeds. A feed check and overload safety system ensures that a stoppage in the feed movement caused, for example, by the work sticking in a tool, will not result in damage either to the feed mechanism or to the tool. Similar safeguards apply if a workpiece is not ejected from a tool.

Protection against overload of the press is by means of a pressure control device. Pressure in the lubricating oil circulation system and the operating air pressure are also strictly controlled. Should the pressures fall below pre-set minimum values the press is automatically stopped. All the requirements for a fully automatic, continuously operated machine, it is claimed, have been met. When running, it does not require continuous attention and thus the operator can tend other machines.

Transfer presses of this size and having high pressure capacities represent a new development that may well exercise an influence in future production planning. The advantages claimed for such presses over conventional press lines are substantial:

1. Production rates are high, and to attain the same output by the use of individual presses would require two or three lines.
2. Floor space occupied by a transfer press could be approximately only one-fifth the area required for the press lines.
3. A transfer press requires only the part-time attention of a single operator. Press lines could need from ten to twenty operators.
4. Power consumption of the transfer press is only about one-third of that needed for press lines of equal output.
5. In consumption of compressed air—a not inconsiderable part of production costs—the difference is even greater than for electric power.
6. A transfer press, due to the type of feed mechanism employed and the relatively close pitching of the tools, requires only a minimum of switchgear units, and controlling and safety devices. For press lines, a considerable multiplication of such items becomes necessary. Consequently, they are rendered more susceptible to breakdown and will demand more maintenance. Down time and loss of production will be greater.
7. A transfer machine creates but little noise; far less than emanates from a number of individual presses and the necessary handling equipment between the presses. It is thus conducive to improved working conditions in the shop.
8. The operating cycle of the transfer press is fully automatic and all movements are under electrical control. Should a fault in operation develop, it is indicated automatically, and simultaneously the machine is stopped. Only when the machine is at rest are safety devices out of circuit and inoperative. The risk of accident is virtually eliminated.

Pearson Panke Ltd, 1-3 Hale Grove Gardens, London, N.W.7, are sole agents for the L. Schuler AG in Britain.

Sealing Pipe Threads

THREADED connections in pipework systems can be sealed by PTFE tape wrapped around the male element of the joint. HILFLON tape, ½ in wide × 0·003 in thick, is manufactured for the purpose by William Rose Ltd, of Lockfield Avenue, Brimsdown, Enfield. It is produced, as standard, in a roll 520 in long, but variations in width and thickness are available to meet specific demands. The tape has exceptional resistance to corrosion, never hardens, and is self-lubricating, so that joints can be easily broken. A particularly useful application is where imperfect threads occur.

COLD FORGING OF STEEL

Advanced Techniques Offer Substantial Economies in Mass Production. Complete Lines of Specialized Production Equipment Now Available

FOR many years the shaping of metals in the cold by a forging technique has been a perplexing problem facing industry. As compared with conventional manufacturing methods, it presented the possibility of substantial reductions in the specific cost of metal, consumption of metal, heating, machining, labour, and production time. The post-war need for mass outputs and increased rates of production, coupled with the mechanization and automation of manufacturing processes, opened up more and wider potentialities in the application of the cold-forging technique to steel. Until relatively recent times, the advances that were made were due primarily to the intuition, skill, and experience of engineers in industry rather than to the theoretical consideration of the mechanics of the cold-forging process. During the last few years, however, an increasing amount of theoretical work and research has been done in Britain and overseas, notably in Germany and the U.S.A.

The author of the first text book on the subject,* Dr. H. D. Feldmann, is the Technical Director of Cold Forging Ltd, Sunbury-on-Thames, one of the Camp Bird Group companies. He has published many papers of theoretical and practical value and instigated much practical development in his private company and its associate companies in West Germany. These companies are now commercially producing cold forgings in the new field of small components. Early cold forging developments were confined to large components formed on heavy, slow-moving presses. It was at the works of Kabel und Metallwerke Neumeyer A.G. in Nuremberg, where Dr. Feldmann previously was Chief Development Engineer, that the cold forging of steel was first developed in the mid-1930 years. Exploitation of the process began with the manufacture of shell and fuse cases during World War II. They have since continued the manufacture of heavy cold forgings in peacetime.

Research and development

Much theoretical work on plastics shaping has been done, and reports on some aspects have been published, since the end of World War II, and the required faces and pressures as well as stresses and velocity distribution can be calculated from these sources. Some of the problems of cold forging of steel may be resolved by the laws derived by Hencky[1], for shear slip in plastics bodies. Work by Hill[2], Ford, Green, and co-workers in England; by Prager[3], Hodge, and Thompsen[4] in the United States; and by Jordan[5] and Kochendorfer, among others, in Germany; has also helped to co-ordinate theory with practice. Studies in the basic mechanics of the deformation of steel at the National Engineering Laboratory, East Kilbride, have been described by H. Ll. D. Pugh†, and much work is in progress there on the influence of the design of cold forming dies.

It is apparent that development and experimental work is under way all over the country. The British Motor Corporation Ltd, Cold Forging Ltd, Forgings and Presswork Ltd, Guest Keen and Nettlefolds (Midlands) Ltd, Production

* *"Fliesspressen von Stahl". Springer Verlag, 1959, Germany. This book has been translated into English and will be published in the Spring of 1961.*

† *Head of Plasticity Division, National Engineering Laboratory.*

Typical components for the motor industry produced by Cold Forging Ltd. Left to right: ball stud, generator pole piece, brake switch housing, and door rotary lock part

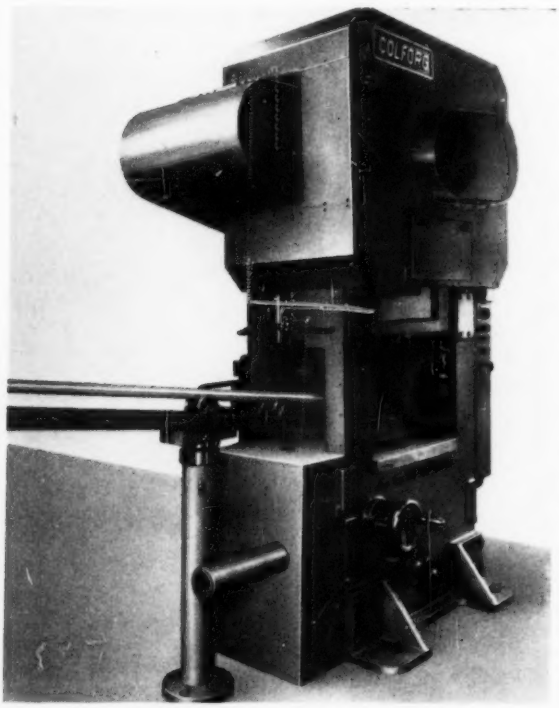
Engineering Research Association, Raleigh Industries Ltd, and the Royal Ordnance Factory, are all known to be actively contributing to this. However, very little detail of any progress is being published owing to the highly competitive potential the technique shows for replacing existing and established methods of production. In Britain there are a few factories only where the cold forging technique is being used internally as part of the production set-up. Even in these, the application seems very limited, and often it does not realize to the full the economic advantages that could be obtained.

In the post-war years German industry, in particular, has been studying how to devise applications of the technique for the manufacture of an ever-increasing variety of articles. As an indication of the prominence that cold forging techniques have in manufacturing processes in Germany, the German Association of Production Engineers has a committee for Production Methods in Cold-forming, and a special Group for Cold Forging under the chairmanship of Dr. H. D. Feldmann. The close collaboration of the foremost production specialists in this field, and of leading universities, has earned this committee much praise for the work it has done on the specific investigation of this technique and in the training of young engineers. Numerous VDI specifications, or "work-sheets", covering the most important branches of cold-forming techniques have been published.

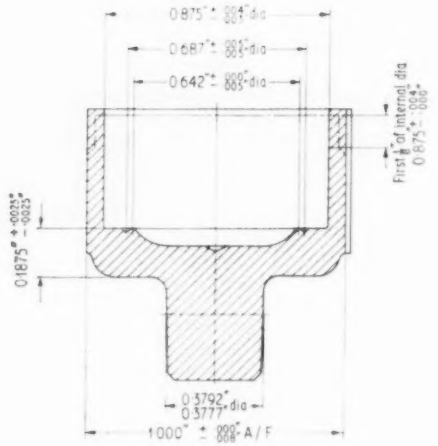
Commercial recognition of cold forging has markedly advanced in Germany. In contrast, industry in Britain has been slow to accept and utilize the technique. This state of affairs has probably arisen from an initial failure to appreciate the wide economic potentialities of the process immediately after World War II and later to the lack of published information on the subject. That the situation is now rapidly being remedied is evidenced by the Institution of Production Engineers National Conference on "Modern Trends in the Manipulation of Metals" in October of this year, and the Institute of Sheet Metal Engineering Special Conference on "Cold Extrusion of Steel" in November.

Complete production equipment

Cold Forging Ltd. manufacture complete production installations for cold forging steel components at high output rates. The equipment comprises cropping, preforming and automatic surface-treatment machines and high-speed mechanical presses. Special hydraulic presses are under development for the forging of larger components. They also produce a large number of small components under contract at their factory at Sunbury-on-Thames, particularly for the automobile industry. These forgings have been carefully selected and the tooling so designed that the full economic advantages provided by the technique may be secured. Wherever possible, components are finished entirely by forging, but where necessary or desirable a minimum amount of machining is performed subsequently.



Colforg cropping machine with automatic bar feed. Bar straightening and slug flattening equipment is incorporated



Section of brake switch housing. The machining of the open end is shown in broken line

The emphasis placed by this firm on "complete production installations" illustrates the difference between small-component and large-component forging. To make the small-component process economic, it has been necessary to devise novel, high-speed, cropping machines to replace saws for the production of blanks or slugs. New and improved heat-treatment and surface-treatment plants have had to be designed to keep pace with cold forging machines having throughputs of from 2,000/hr to 6,000/hr. This difference can be best shown by studying the processing of a small component, of which thousands are required every day.

A typical component, manufactured by Cold Forging Ltd, is the housing of a hydraulic switch used in the brake-light circuits on many modern cars. This was previously made by machining from a cold-rolled, hexagon, steel bar of a 0·20 per cent carbon, free-cutting type, having a tensile strength of 35 tons/in^2. Machining resulted in an enormous wastage of material, amounting to 70 per cent of the original bar stock, in the form of turnings or swarf which can be disposed of only at scrap-metal prices.

By cold forging the housing, after a comprehensive study by the Chief Development Engineer, Mr. R. S. Hayward, of the component and the specific tooling requirements, it is now being produced at the rate of 60/min. With a minimum amount of finish machining required subsequently,

Brake switch housing. Top, slug as cropped and flattened; centre, interior and exterior as forged; bottom, as machined and final assembly

only 10 per cent of the original stock material is scrapped. The necessarily high pressures employed in forging, considerably increase the tensile strength of steel. Accordingly, a much cheaper, hot-rolled, low carbon steel can be used. A typical steel for the purpose could have a composition of C 0·05-0·07, S 0·017, P 0·029, Mn 0·28, and Si 0·5-0·20 per cent, and its tensile strength will be raised to approximately 48 tons/in^2 by cold forging.

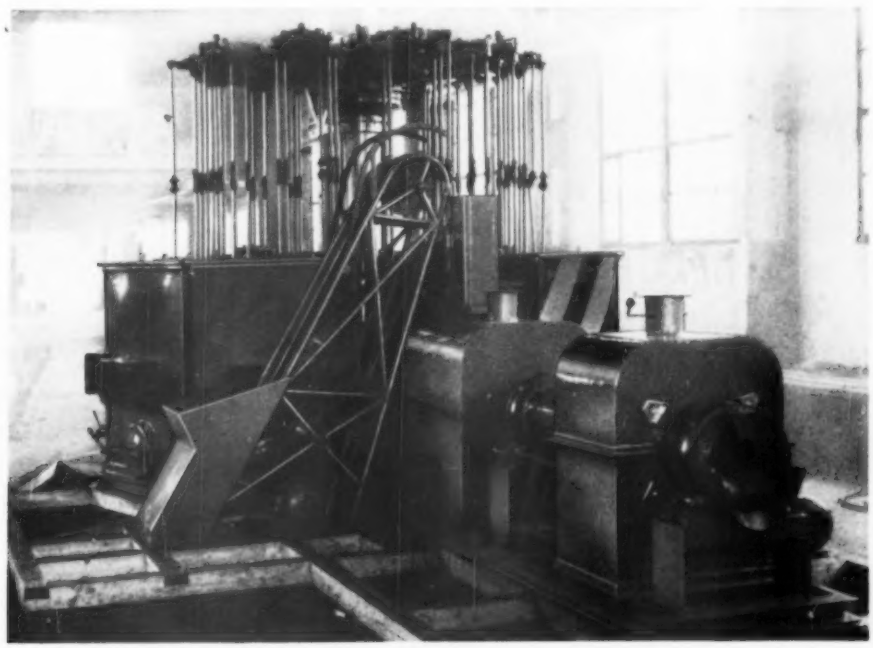
The cold forging of this component involves a sequence of six operations: cropping and flattening, phosphating, preforming, annealing, phosphating and forging. The slugs are cropped from the bar and flattened on a special high-speed automatic machine, the bar being first straightened by an attached straightening unit and then fed to the tool at a predetermined angle depending on the properties of the material. The flattened blanks are then submitted to descaling and a first phosphating treatment.

Surface-treatment plant

This is carried out in a multi-tank, carousel-type installation. From the arms of an elevating and indexing spider mounted on a central column are suspended the basket-type work containers. In their lower position, while submerged in the solutions, the baskets are automatically oscillated in two vertical planes at right angles in order to tumble the parts and ensure their uniform exposure to the solutions. Operating on a cycle time of up to 8 min, this equipment is capable of a throughput of up to 1,320 lb/hr, or about 22,000 switch housings/hr.

The treatment takes the form of a zinc phosphating process which is carefully controlled to maintain a uniform coating of predetermined thickness. By weight, the coating produced is approximately 1·0-1·5 g/ft^2 of the surface area of the work, equivalent to a thickness of about 0·15 micron, in order to avoid unnecessary build up in the tool and the consequent limitation of its life. On discharge after phosphating, the parts are conveyed and fed at a regulated rate to a horizontally arranged lubricating unit. There they receive a final treatment with a solution of Bonderlube, a sodium stearate-base soap which includes a rust inhibitor. The parts are progressed through the lubricating tunnel by a screw conveyor. This pretreatment process is of extreme importance in the efficient application of the cold forging technique, and must be closely controlled.

After preforming — a press operation — the shape is annealed in an atmosphere-controlled, pit-type furnace to produce a metal structure most suitable for further cold forging. Only the strict control of temperature of this annealing operation and the careful design of the tooling for the preforming and final forging operations enables the



Automatic pretreatment aggregate. After phosphating on the carousel plant the parts are treated with Bonderlube

maintenance of the close dimensional tolerances which are demanded. For example, the internal diameter is held initially to within size and + 0·004 in and thereafter to within +0·004 and −0·003 in tolerance in taper to the base. The stem is held to within 0·0015 in on diameter. Other limits are given on the line drawing of the part.

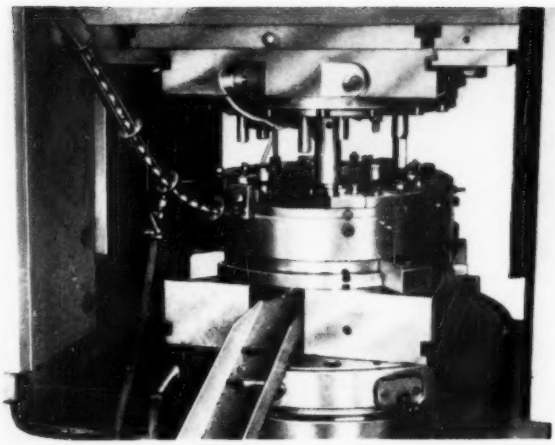
Press tool life

The final forging operation is a combined backward extrusion and forward extrusion. Die life now averages better than 100,000 strokes, and punch life is between 15,000 and 25,000 strokes. Not all components, of course, require two forging operations or annealing between those operations. Some are produced in a single stroke and others by multiple strokes in a progressive die set-up, without interstage annealing.

This switch housing is produced for a firm supplying electrical equipment to the automobile industry. It subsequently requires machining only at the open end of the body to produce a thin lip for swaging over and retaining a plastics terminal moulding, and the drilling and external threading of the stem. The machined forging is cadmium plated before the assembly operation and each switch is tested hydraulically, up to a pressure of 8,000 lb/in^2, before dispatch.

It provides an example of how industry can gain economic advantage by the use of the cold forging technique. The table indicates in approximation how by the use of a lower grade of steel and by improving the ratio of metal utilization the material cost of the component can be greatly reduced. Additionally, the rate of production is high, skilled machining time is reduced, and swarf handling lessened.

The field of application is very wide. In the automobile industry, such components as spur wheels, bevel wheels, spark plug bodies, bushes, bearing sleeves, brake actuation cylinders, door lock parts, generator and starting-motor pole pieces and casings, and ball-race housings can be manufactured with substantial economy by this method. Many of these items are already being produced by Cold Forging Ltd, at Sunbury. In fact, almost any steel component having approximate axial symmetry is worthy of consideration for manufacture by the cold-forging process.



Multi-station tooling, with automatic feeding of slugs, for nut forging

At the recent International Machine Tool Exhibition in Hanover, the experience of firms producing cold-forging equipment showed that more than 80 per cent of the enquiries received came from German concerns. One German automobile manufacturer required a quotation for a cold-forging installation to manufacture no less than 250 components for a single vehicle. From this, and widespread interest in other industries, it is not unreasonable to deduce that in Germany cold forging is now regarded as a standard practice. Although cold forging application in Britain has hitherto been relatively slow, it is now increasing at an accelerating rate; a trend that may be expected to continue.

P300 Colforg press with multi-station tooling

COMPARISON OF MATERIAL COSTS

Stock material	*Approximate cost per ton*	*Method of production*	*Material to waste during manufacture, per cent*	*Approximate cost of material per piece*
Free-cutting steel, (En 1A, En 1C) bright-rolled hexagon bar	£70-75	Machining from bar	approx. 70	3d
Low-carbon steel, hot-rolled bar, En 2A, high grade	£52-56	Cold forging	approx. 10	0.5d

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Plastics Trim and Upholstery

A Range of Radyne Press Welding Machines and Fabricating Equipment for Mass Production

THE first radio-frequency (R.F.) press welder to be used in Britain for the mass production of door casing boards was a Radyne unit, built by Radio Heaters Ltd, Eastheath Avenue, Wokingham, Berkshire, and installed in a Birmingham car factory in July 1954. Since then large numbers of Radyne welders have been acquired by car manufacturers and their suppliers in all parts of the world for the production of door and quarter casings, and many other component items. Currently, these include sun visors, transparent rear and quarter lights for collapsible hoods, cushions and squabs for seating units, roof linings, grommets for edging apertures in carpets, carpet edgings, arm rests, door pulls, step coverings, tool rolls, instruction manual covers, and spare parts packages.

Radio-frequency welders are also used in the pre-creasing of leather panels prior to stitching into flutes for seating. Another application is the welding of complete seating units, including the fitting of decorative piping into the seams; a new technique at present in process of development. A Radyne W/2P press welder being used to pre-crease a pre-cut leather panel before fluting is shown in Fig. 1. By employing this method of pre-creasing, rather than the traditional method of folding and rubbing down with a bone, the crease marks are permanently impressed in the material and, consequently, mass production methods can be adopted. Using the conventional method, the leather makes a fairly rapid recovery and thus creasing and stitching must be closely sequenced operations. It has also been found advisable, in some instances, to pre-crease heavy-duty, seating-quality, supported plastics materials permanently to enable the flutes to be stitched more readily and more accurately.

An example of the more recent development, previously mentioned, is the seating unit in Fig. 2. It shows a decorative piping fitted round the border material and also a roll welded into position. This particular unit is made with a heavy-duty, seating-quality, supported vinyl material, and the quilting medium is foamed vinyl with a scrim backing. Although traditional materials have been used, no stitching whatever is required.

Radio-frequency welding process

Radio-frequency welding of plastics sheet is basically a form of heat-sealing, employing a generator that converts a normal electrical mains supply current to a very high frequency. The layers of materials to be bonded together are held between shaped dies or electrodes, and the radio-frequency power from the generator is applied to the electrodes. If the material possesses the necessary "loss factor" it will absorb energy from the radio-frequency field

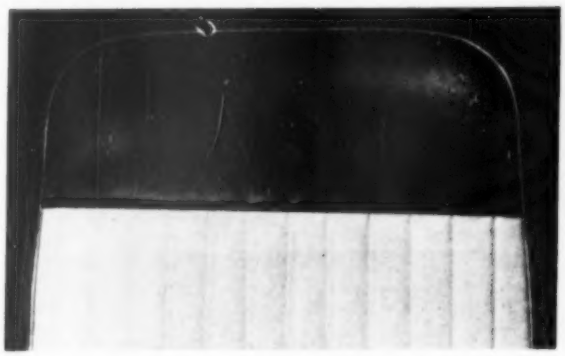


Fig. 2. Decorative piping in seams of all-welded seating unit

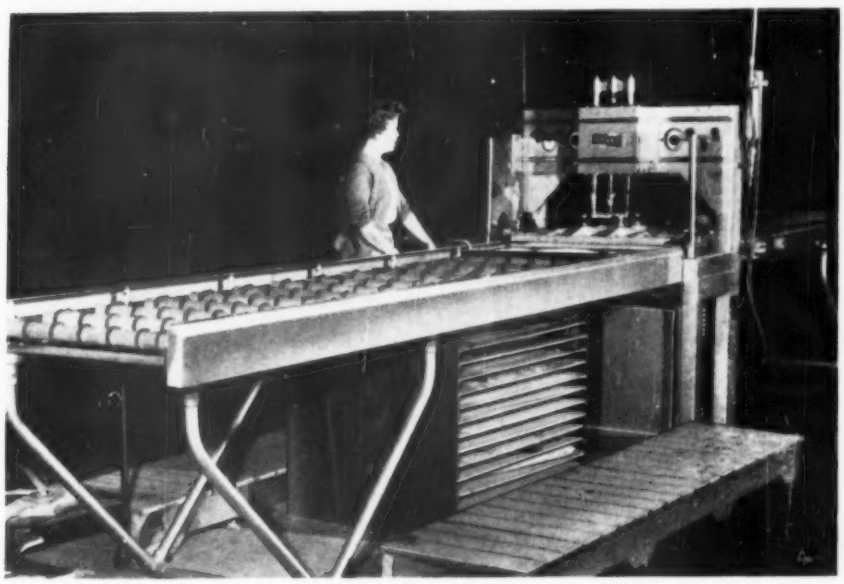


Fig. 1. Pre-cut leather upholstery panels are here being permanently creased on a Radyne R.F. welding press ready for subsequent stitching

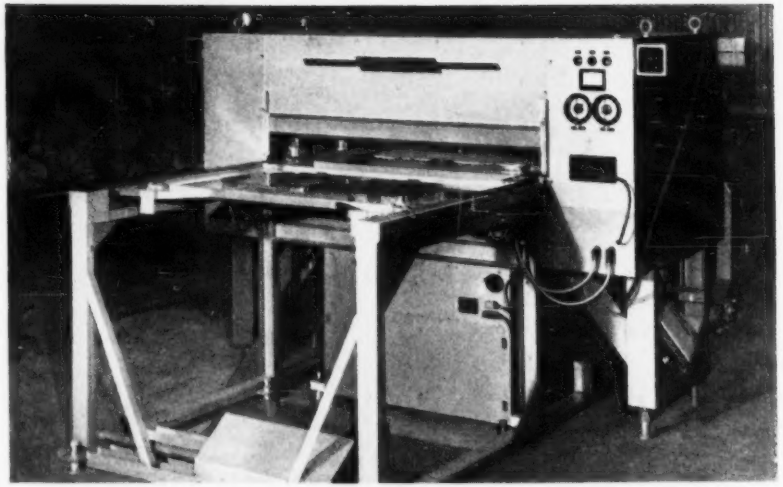


Fig. 3. Automatically indexing, double-shuttle, loading equipment on large press

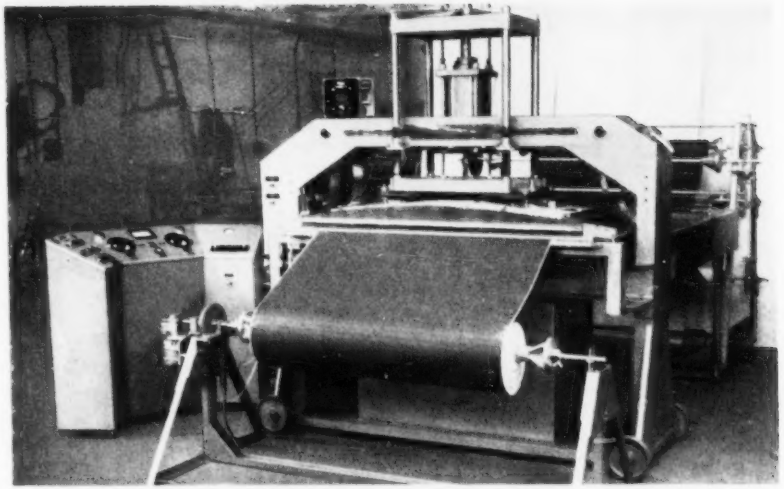


Fig. 4. Production of quilted material on a continuously indexing, Autodex machine

Fig. 7. One operator tends two presses bonding door casing boards

Fig. 8. Circular track loading set-up for multi-pattern trim panels

passing through it. This energy, which appears as heat in the material, is caused by molecular friction in the material, the temperature of which is raised very rapidly to fusion point at the interfaces. Since the dies or electrodes are kept relatively cold, the surface of the sheeting remains cool, and thus the maximum temperature is at the inner surfaces of the sheeting being bonded. Radio-frequency welding is, therefore, a unique method of sealing, and does not depend upon conduction of heat from the outside to the inner layers of materials.

Many thermoplastic materials readily heat in such an electrical field and are consequently suitable for radio-frequency welding. These include polyvinyl chloride (P.V.C.), certain grades of nylon, acetate, vinyl-based compounds, and similar materials. On the other hand, radio-frequency welding is uniquely suited for bonding together materials such as fabrics which cannot normally be welded. In such cases it is necessary to use a thermo-setting or thermoplastic adhesive, which can be set or cured much more quickly by R.F. current than by any other means. Radio-frequency bonding has the advantage that the outer faces of the materials being bonded do not have to be heated before the bonding agent is set or cured.

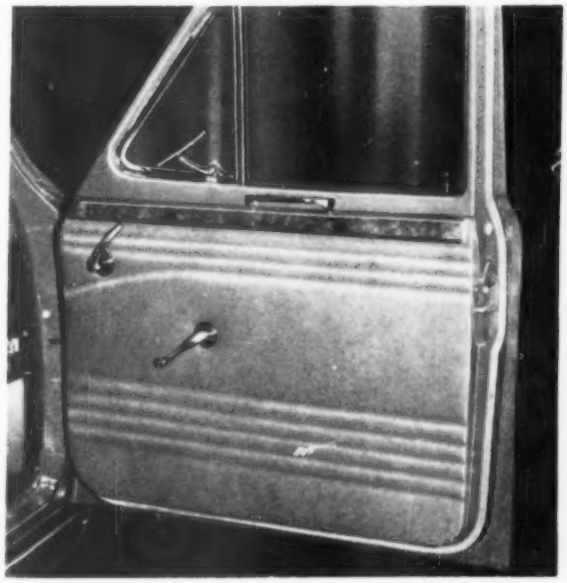


Fig. 6. Flexible P.V.C. sheeting on Singer Gazelle door casing board

Automation

With the greatly expanded production of motor vehicles, coupled with an increasing premium on floor space in the manufacturing plants, it has become necessary to apply automatic operating equipment to the presses so that they can be more fully employed. To some extent, this has been achieved by automatic, double-shuttle, loading assemblies and by automatic indexing gear. The former method is the more adaptable to welding assemblies that have to be pre-cut to shape, and several parts aligned with each other. One station is used for loading the parts, whilst the other is the operating station at the welding press.

Fig. 3 shows the Radyne Model W/4P/E 30 kW press welder fitted with an automatic, double-shuttle, loading assembly. Apart from loading the patterns on to the special jigs, the operator has only to press a button to initiate the automatic indexing of the work and electrodes, the weld cycle, and the return of the tray for unloading and reloading with unwelded patterns. This illustration shows one indexing tray fitted with electrodes for welding Austin Seven bucket seats, whilst the electrodes inside the press are for making Austin Seven bench seats. Press welders equipped with automatic indexing units of this type are now being used by many British manufacturers, including B.M.C, Vauxhall, Rootes, Standard-Triumph, Ford, Jaguar, Fisher and Ludlow, Pressed Steel, and others.

In many factories, female labour is used to operate plastics sheet welders and, in fact, the welders are generally designed so that women and girls can easily operate them. Some work, however, necessitating the lifting and laying-out of large hardboard or plastics panels, can be tiring if the machine operator has also to push and pull heavy trays, no matter how easy-running they are. Automatic assemblies allow the operator a few seconds rest period while the assembly she has been loading is being welded. This few seconds is also valuable inasmuch as the machine instru-

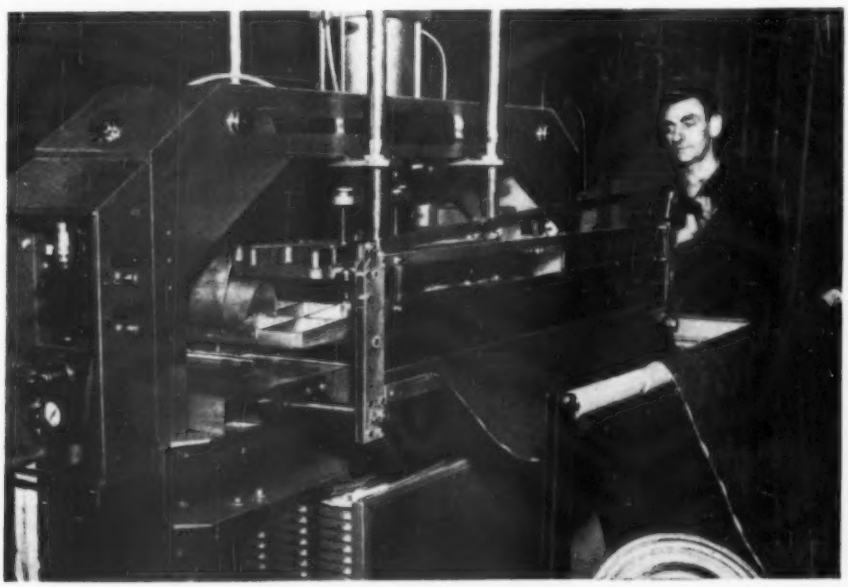


Fig. 5. Quilting material on a Radyne manually operated, continuously indexing press

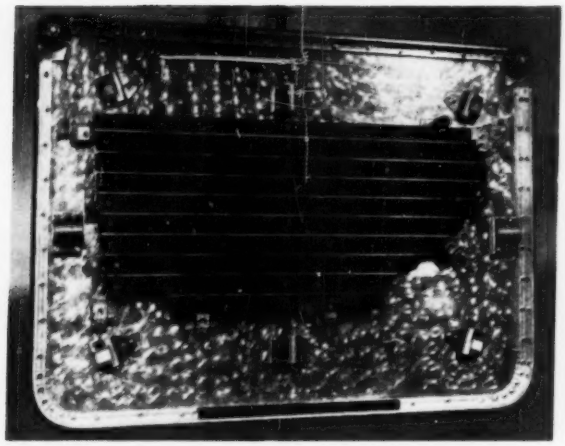


Fig. 9. Portable electrode, with pattern locators, for the track assembly of quilted trim panels

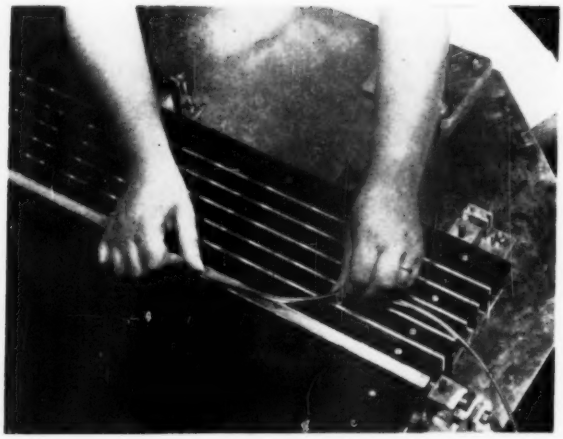


Fig. 11. Showing method of applying extrusion before lay-up of sheets for a door trim panel

ments can be observed, and if necessary adjustments made. This is sometimes useful in cases of electrical mains voltage fluctuation, or excessive variation of air pressure.

The automatic indexing attachment to welders is usually employed when welding is done on materials that are being fed directly from rolls, and very accurate indexing can be maintained when using suitable equipment and materials. A Radyne Autodex unit manufacturing continuous quilted products is shown in Fig. 4. This unit, apart from the fitting of rolls of material on to the roll holders, is completely automatic.

With regard to the continuous indexing type of equipment, once the rolls of material are in position, one machine minder can, if necessary, look after two or more machines. On this type of equipment, the main function of the machine minder is to ensure the alignment of the materials being welded. Due to the flexibility and uneven stretch of such materials as unsupported P.V.C. sheeting, plastics foams, or bonded fibres, it is not always easy to retain alignment by mechanical methods. The use of photo-electric cells and hydraulic or pneumatic shunts has been tried, but these can be effective only if the materials are well rolled under even tension.

Manually operated versions of both the double-shuttle and indexing assemblies are available. The speed of production on the manual types, especially the shuttle, may be equal to fully automatic gear, but the latter will eliminate operator fatigue. Fig. 5 shows a manually operated version of a continuous indexing unit.

Door and quarter casings

Several variations of door trims are being produced at the present time and the trend would seem to be towards more decorative effects. Many cars now have door trims incorporating welded decorative extrusions. Most R.F-bonded trims consist of hardboard $\frac{1}{10}$ in or $\frac{1}{8}$ in thick, a heat-setting adhesive, plastics foam or fibrous wadding, as quilting media, and either cotton-supported or unsupported P.V.C. sheeting. The R.F. bonding gives a quilting effect to the plastics sheet by bonding it through the foam or wadding

Fig. 10. Two-tone door trim with decorative extrusion on Standard Vanguard

Fig. 12. Simulated embossing on continuously quilted material for coach trim

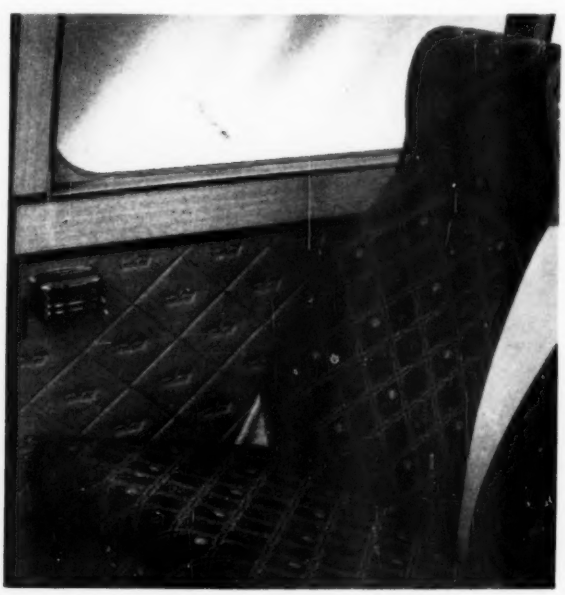


Fig. 13. One-hit, shallow-quilted effect for seats and squabs

to the adhesive and hence to the board. Adhesives used are usually polyvinyl acetate (P.V.A.) emulsions, spread on the board to a weight of about 10 g/ft², either over the whole of the board or stencilled in the position of the bond lines.

Another widely used method of bonding the P.V.C. sheeting and padding to the board is by using a scrim tape, one side of which is coated with P.V.A. and the other with P.V.C. During the welding cycle, the P.V.A. side of the fabric bonds to the board whilst a bond is made between the P.V.C. side and the outer covering of the trim pad. This method gives the strongest bond between the outer plastics sheeting and the board, although with any pad that has been properly bonded it should be possible to de-laminate the hardboard by a direct pull along or against the weld. Detachment is not possible, of course, on the completed trim when the margins of the plastics sheet have been turned over the edge of the board and the component has been fitted into position.

The most widely used padding media are polyurethane foam about ⅛ in thick, or bonded acetate fibres of about 2 oz/ft² density. In both instances, during the welding cycle the top P.V.C. sheeting flows through the foam or wadding, which is compressed by the electrodes and subsequently broken down, giving a direct bond to the board with the aid of the adhesive or the coated scrim. Currently, developments are being made to perfect the production of door casings, so that the need to turn the material around the back of the board for sticking or stapling is obviated. It is hoped that by including a further layer of very thin P.V.C. film, say 0·003-0·004 in thick, on the back of the board and welding it to the front P.V.C. pattern, an expensive labour operation will be saved. The weld, which would be tight around the edge of the board, could be either decorative or plain and of the tear-seal type. Thus, any surplus material could be simply torn away from the outside of the weld.

Such outside welds would be made at the same time as the quilting or bonding welds, and it is appreciated that the "fullness" of the pad must be maintained. A further advantage is that the front P.V.C. pattern could be cut approximately one inch smaller all round which would represent a substantial saving. Unsupported flexible P.V.C. sheeting is now generally accepted for bonded door and quarter casing boards. An example is the Singer Gazelle front door, Fig. 6.

Casing boards are bonded on Radyne four-pillar presses. As the illustration Fig. 7 shows, two presses can be loaded and unloaded by one operator. A circular track unit upon which a series of portable electrodes are loaded before being fed into the press welder, is shown in Fig. 8. This type of loading unit is employed where several varying patterns are used in the make-up of a single trim unit.

Typical of the electrodes used on such so-called tray-loading systems is that illustrated in Fig. 9. The electrode is the lower press tool, with special spring-loaded location pieces which hold the various P.V.C. patterns, board, and quilting medium in position. Support rollers and guide wheels are fitted to the tool to facilitate tracking as it is shunted around the table to the various loading stations.

Decorative effects, other than by such embossings as simulated stitch marks made by engraved electrode welding surfaces, are normally made by the welding into position of P.V.C. extrusions. These can be made to almost any regular sectional shape, and some have a decorative metallic foil embedded in them. Another type used has two or more

Fig. 14. Loading special bottom electrode for deep-fluting heavy seating material

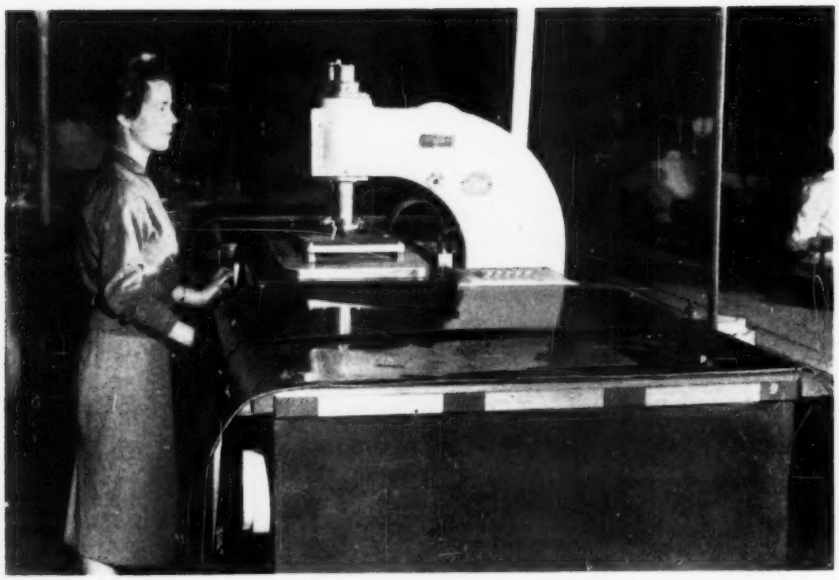


Fig. 15. Welding transparent P.V.C. backlight into plastics hood material

intertwined round sections. Whatever the section and make-up, however, the extrusion is first fitted into a shaped channel in the electrode before the alignment of the material lay-up. During the heating cycle the extrusion is then bonded to the P.V.C. sheet.

On the Standard Vanguard, Fig. 10, and Humber Snipe, for instance, these trims have a decorative extrusion welded in at the same time as the remainder of the bonding is undertaken. In Fig. 11 is shown the method of applying the extrusion to the special welding surface on the electrode before the sheets are laid up. The effect of embossing by means of motifs built on the electrode can be seen on the panelling in a coach, Fig. 12. This has been made by fitting continuously welded quilted material over a pre-cut panel.

Seating units

Up to the present, welded seating units have not been used in as many cars as have R.F-bonded door casings. The number is increasing, however, and tests are currently being made in this connection by many manufacturers. Traditional straight-line fluting is generally used on cars that have welded cushions and squabs, and although the welding of these shows a saving on some existing production lines, it does not exploit the full capabilities of a R.F. welder in relation to the possible design of this type of component. In other words, varying types of seats and squab units which are impossible or impracticable to make with a sewing machine and traditional trim methods, can be produced on a R.F. welder.

The material lay-up in an average seat and squab consists of the top material, which is usually of a fabric-supported P.V.C. sheeting, a foamed plastics material as a quilting medium, and a base of scrim or hessian fabric or, in some instances, a P.V.C. film. Sometimes the base material, if a fabric, is coated with P.V.C. but this is not necessary if the quilting medium is vinyl foam, rather than polyurethane foam or polyether foam. This is possible since, during the heating cycle, vinyl flows into the fibres of the fabric giving a degree of adhesion that is quite adequate for the purpose. Treated or coated fibre products can also be used as the padding, although this is somewhat detrimental to the "give" of the seat.

Whether the shaped tool is fitted to the top or bottom electrode carrier, if the three materials used in the seat or

Fig. 16. Weatherproofing stitched seams in hood material by over-welding

Fig. 17. Production of rigid-frame visors on Radyne W.21 press welder

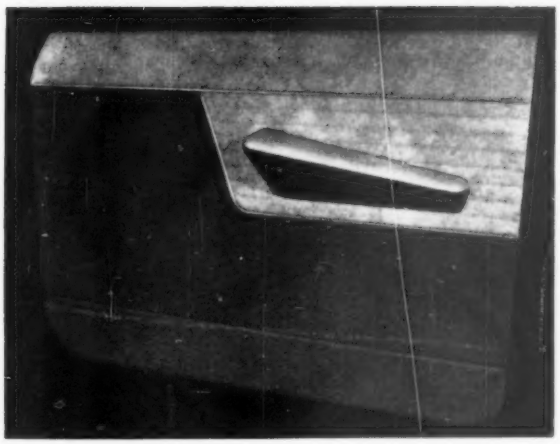
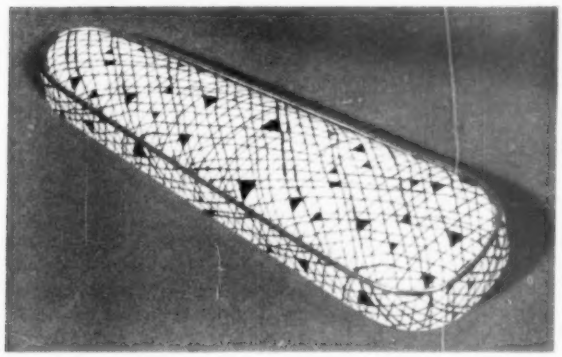


Fig. 18. Two-coloured arm rest with vacuum-formed parts welded together

Fig. 19. Completely welded arm rest with piping of extruded plastics



squab are placed directly on to the electrode or pressplate and the whole welded in a single "hit", the appearance will be rather "flat", and a shallow quilting effect is the result. A seat made by this method is shown in Fig. 13. Whilst the seat may not have the deep-fluted, luxurious appearance of seating units used in the more expensive range of cars, it is equal to, or in some cases better than, many stitched seats in cars of a similar price range.

To obtain a full fluting effect it is necessary to pre-form the top P.V.C. material to the shape required, and this can be done by having the fluting electrode as the bottom tool, and pre-forming the material, prior to the welding cycle, to the required depth of flute by means of bolsters or fingers. By pre-forming the material in this way, the required shape is more readily obtained, and the quilting medium need not necessarily be weldable or easily broken down by pressure and heat. In other words, pre-formed pieces of foam or wadding can be placed in the formed parts of the cushion or squab as long as it is possible to weld the top and backing materials together. It is, nevertheless, advisable to use at least a thin layer of weldable foam or wadding, otherwise crinkling can occur along the edges of the welds.

It is not necessary, however, to have the top material of a weldable nature if vinyl foam, or at least a sheet of P.V.C. material, is used as a bonding agent between the top and bottom materials. For instance, a fabric such as uncut moquette or even leather could readily be used as the top material so long as it is possible to weld through the padding substance and bond the top sheet to the bottom sheet, either by one or both interfaces being coated with a thermoplastic adhesive or paste. Alternatively, the fibres of the inside of the top and bottom layers should be "gripped" with thermoplastic material from either a P.V.C. foam padding material or the coated base fabric or plastics sheeting, which will become sufficiently molten to flow into the fibres during the actual welding cycle. A thermosetting adhesive could be used in place of the thermoplastic sheet or foam, but the spreading of this may present difficulties.

It should be noted that there are other ways of forming the top layer materials, prior to welding, such as the vacuum processs, but the materials that can be formed by this method are limited, and the inclusion of vacuum boxes in the welder is frequently impracticable. In Fig. 14, an electrode assembly is being loaded prior to welding, and the adjustable insulated "fingers" are being clipped into position, thus forming the required depth of flutes. After welding, all the fingers are released by a single quick-action device and the complete unit is easily slid away from the assembly.

It is not always advisable to make the profile or edge weld of the squab or cushion unit at the same time as the quilting or fluting welds, since this can prevent the stretching or "forming" of the top material. In many cases, if the maximum fullness of the unit is required, it is necessary to make the profile weld as a separate operation. In other instances, it may be possible to weld the roll or edging into position at the same time as the profile weld, but this depends mainly on the design and the shape of the seat.

Hoods, lights, and visors

Before the R.F-welding technique was introduced into car trim manufacture, hood backlights and quarterlights, like many other components, were stitched in position. As with the stitching of all plastics materials, the perforations caused by stitching considerably weakened the unsupported transparent window. The other major objection to this type of fabrication was that the stitch holes were not watertight unless a dope solution was applied over the stitches. The same consideration applied to the seams in the hood itself.

As a consequence, the window material was changed to a transparent semi-flexible P.V.C, upon the formulation of which a great number of tests had been carried out to improve durability and vision in service. It then became possible to use R.F. welding to bond the transparent P.V.C. panel to the supported P.V.C. hood material, thus producing a much stronger, watertight, and more easily folded hood. Some manufacturers use a specially engraved tool which

Fig. 20. Welded-up capping for sills on Citroën cars

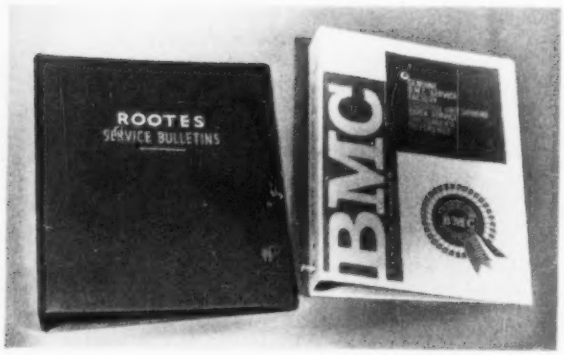


Fig. 22. Two examples of welded plastics loose-leaf binding covers

gives a neat decorative effect around the margin of backlight.

The Radyne PW.50 welder, Fig. 15, is shown being used in the production of welded backlights. Because of the flexible nature and size of the hood material it is impracticable to locate the material if the window aperture is cut out of the hood before welding. Accordingly, to assist location of the transparent P.V.C. pattern, the surplus sheeting from the hood is best trimmed after welding. The backlight itself is pre-cut to shape before welding and thus requires no trimming after welding.

To obviate stretch in hoods, it is necessary to use a heavy P.V.C-coated fabric, and the strongest weld that can be obtained on such a material, obviously, is only equal to the adhesion of the P.V.C. to the fabric. This is not normally sufficient to resist the wear and tear to which hoods are subjected. Consequently, the parts are first stitched together to form the hood, and then the seams are over-welded so that the flow of P.V.C. during the welding cycle fills in the stitch holes making the seam watertight. Because of the number and complexity of shaped tools that would be required, it is preferable to use a small, pedal-operated welder, as in Fig. 16. This shows an early type of welder; more up-to-date units are now available, although the method and speed of operation is still about the same.

Visors are generally produced by specialist suppliers to the industry. Sun visors made by the R.F-welding process are usually covered with unsupported P.V.C. sheeting. In addition to the weld around the outside of the visor, a quilting weld is sometimes also made. While the profile weld is often also decorative, some manufacturers prefer as thin a weld as possible, or even a weld that is almost flush with the cover material itself. Either stiff or flexible frames can be provided. Sun visors with a rigid frame are being produced on a Radyne Model W.21 press welder in Fig. 17.

Minor trim and accessory items

Arm rests can be made by a variety of methods. One shown in Fig. 18 is partly vacuum-formed and partly welded. Since it is made from two different-coloured materials, the formed parts have to be welded together, either before or after forming depending upon the required shape. In Fig. 19, however, is an arm rest that is welded complete with a decorative extruded plastics piping. This particular example was not intended to be used in a car, but is a similar type of component, and one that can be made without any vacuum forming process, thus reducing production costs.

On a Citroën car, Fig. 20, is a sill covering consisting of a P.V.C-coated fibrous material welded to right-angled section plastics extrusions. Both welds are made in a single "hit", with special locations to ensure that the extrusions welded to the fibrous material are secured in the correct profile.

Many car manufacturers employ thin P.V.C. film for the packaging of spare parts, especially for the overseas markets. A pre-printed sheet is commonly used and the packs are made in lay-flat, tubular form by two narrow parallel welds. The part is then sealed into the pack by normal straight-bar welding. The tubes are welded continuously on an automatic indexing equipment. A Radyne Junior Autodex, Fig. 21, produces such tubes at a rate of about 45 ft/min.

Welded plastics loose-leaf covers are now in wide use for binding instruction manuals, spare parts lists, and sales literature. Fig. 22 shows two such covers.

Acknowledgement is made to Radio Heaters Ltd, and the following manufacturers for permission to illustrate equipment, operations, and products: Citroën Cars Ltd. (Fig. 20); Duple Motor Bodies Ltd. (Fig. 12); Fisher and Ludlow Ltd. (Figs. 1, 3, 7, 15); John Morgan (Jemca) Ltd. (Fig. 17); Mulliners Ltd. (Fig. 14); Nickwood Plastics Ltd. (Figs. 21, 22); Pressed Steel Co. Ltd. (Figs. 8, 9, 18); Rootes Group (Fig. 6); Standard-Triumph International Ltd. (Figs. 10, 13).

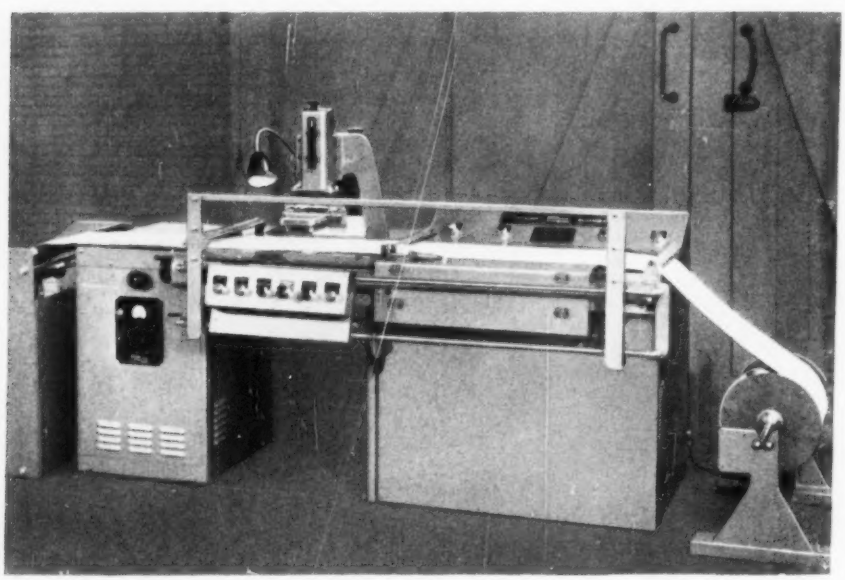


Fig. 21. Lay-flat tube for spare parts packaging is produced on a Junior Autodex machine at rates up to 45 ft/min

Review of British Coachwork

The Specialist Coachbuilders, Still Dwindling in Number, Tend to Concentrate on Bodies for Rolls-Royce and Bentley Chassis

IT is to be regretted that this year saw the absence from the 1960 London Show of yet another of the long established classical coachbuilders, namely Hooper and Co. (Coachbuilders) Ltd, who for many years have been famous for their gracious and dignified bodies on large chassis. Also, of course, Vanden Plas (England) Ltd. is no longer building specialist coachwork but is producing bodies in the series production class. The decline of which these two changes are evidence is possibly the effect of reluctance on the part of the British vehicle manufacturers to release chassis or understructures to coachbuilders for the fitting of special bodies. To provide such a structure involves, in effect, the removal and scrapping of the production body, because in large-scale continuous production it is not economically possible to break down the conveyor line in order to supply a part-assembly. The Continental coachbuilders are in a better position than those in this country, in that the car manufacturers are willing to co-operate with them to a much greater extent. As an example of this, it has just been announced that the Citroën organization has concluded an official arrangement with Henri Chapron to build special cabriolet convertibles on versions of the DS.19 and ID.19 chassis.

H. J. Mulliner convertible drophead coupé on a Rolls-Royce Silver Cloud chassis. The waist moulding extends rearwards from the radiator shoulder and ends at the crown of the rear wing, to accentuate the length

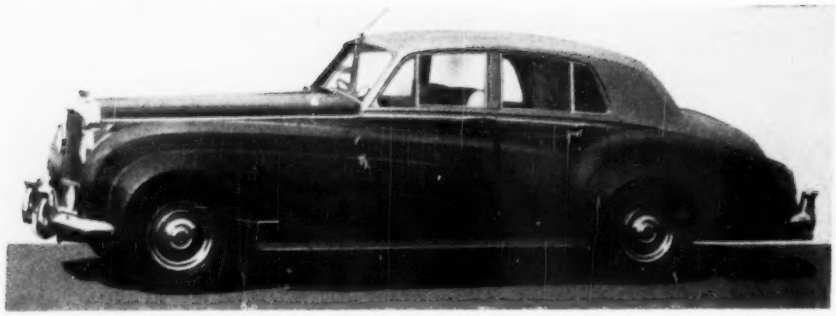
For obvious reasons, specialist coachbuilders such as H. J. Mulliner, James Young and Park, Ward devote their attention to Rolls-Royce and Bentley chassis. Among the companies now specializing in the series production of bodies are Fisher and Ludlow, Pressed Steel Co, Carbodies, Thrupp and Maberley, and Mulliners Ltd. of Birmingham. Of their exhibits at Earls Court this year, about half were actually built by the firms concerned, the other half being conversions of existing models supplied by the manufacturers. E. D. Abbott and Harold Radford concentrate on conversions of standard bodies, the Radford products being based on the Rolls-Royce and Bentley saloons.

As would be expected, the products of the classical coachbuilders are beautifully finished; great attention is paid to designing for really luxurious travel, and the comfort of the occupants is enhanced by numerous well finished accessories. In general, these vehicles have dignified and elegant styling, and the seating and interior treatment generally is of an exceedingly high standard. Increasing attention is rightly being given to sound insulation and dust sealing of the interior. Among the features now finding favour are shock-absorbent rolls at the edges of facias, and hooded instrument panels that obviate annoying reflections on the windscreen. In this latter connection, however, it should be mentioned that the benefit of the hood is nullified on some current examples by the amount of bright plating on the steering wheel and for its associated equipment such as the horn ring, lamp switches and other controls.

H. J. Mulliner and Co. Ltd.

Three bodies recently produced by H. J. Mulliner and Co. Ltd. serve to underline the high reputation enjoyed by this company. They are a two-door drop-head coupé on a Rolls-Royce Silver Cloud II chassis, a four-door six-light saloon on a Bentley Flying Spur Continental chassis, and a two-door four-light saloon on a normal Bentley Continental chassis. The Rolls-Royce Silver Cloud drop-head coupé is mainly of pressed steel, stressed-skin construction but the bonnet is aluminium and the doors and boot lid are aluminium alloy. For the front end, the standard Rolls-Royce units are used; they include the front wings, into which the body lines merge very gracefully. The waistline extends rearward from the top of the radiator in almost a straight line, to end at the crown of the rear wing, and a lower moulding curves gently downward to this wing. As is well known, it is very difficult with such a moulding to achieve artistic results in the rear wing region, but in this case the solution is certainly good.

The front seat is of the bench type and is wide enough to carry three people if necessary. It has a divided squab, each of the two portions of which is individually adjustable



This is the standard all-steel saloon body on the Bentley S2 chassis. So far as practicable, the standard components of this body are used for the variants produced by the coachbuilders

for rake and tilts forward to give access to the rear seat. A folding armrest is fitted to the inboard end of each portion of the squab, and there is an adjustable armrest on each door. The seat cushions are built up on an interlocking coil spring base, and are filled with moulded foam rubber, while the squabs are of rubberized hair. There is room for three persons also in the rear seat, the cushion of which consists of tension springs and moulded foam rubber. A lambswool rug is fitted to the rear floor.

To operate the folding head, which is of fabric-backed p.v.c, an electro-hydraulic system is employed. This comprises an electric motor and a pump that forces fluid from a reservoir into hydraulic jacks. The fluid flow is controlled by electrically operated valves, and a by-pass relief valve is embodied. This power unit is neatly installed behind the rear seat; in the event of a failure of the system, the head can be operated manually. It is worthy of mention that this car received a silver medal in Section 3 of the Institute of British Carriage and Automobile Manufacturers' competition, to which reference was made in the Show Review issue of *Automobile Engineer*.

The Bentley four-door six-light Flying Spur Continental saloon was designed to combine the advantages of this body type with the low lines and compactness associated with the two-door Continental model. In addition, every effort has been made to minimize the weight, to avoid impairing the performance and handling qualities for which the car is renowned. The body framing is all of light alloy and is panelled throughout in aluminium. The slimness of all the pillars not only results in an unusually good field of vision but gives a light and sporting appearance to the car.

This body is intended as a really luxurious four-seater. In the front there are individual semi-bucket seats, the squabs of which are adjustable for rake. The wide armrest fitted between the seats serves as a receptacle for gloves and small articles, and so is fitted with a hinged lid. It is arranged to fold down flush with the cushions when not required. The front seat squabs are of moulded rubberized hair, with a

Noteworthy features of the H. J. Mulliner Bentley Continental, with two doors and four lights, are the width of the windscreen and the slenderness of the pillars

The H. J. Mulliner Flying Spur, four-door six-light saloon on the Bentley Continental chassis

border of foam rubber. That of the rear seat, which has a folding centre armrest, consists of springs on a webbing base, with a foam rubber overlay. All four doors have slip pockets and, in addition, an open, recessed pocket is embodied at the bottom of each front door, towards the leading edge. There is an elbow rest on each of these doors.

The Bentley Continental two-door four-light saloon is a delightful looking car—an admirable blend of simplicity, elegance and relatively light weight. On the example studied, the exterior finish of porcelain white was effectively contrasted with the black hide of the seating, the black carpets and the light grey headlining. The relatively sombre interior gave a very restful feeling, which was augmented by the particularly comfortable seating.

As in the case of the four-door body previously described, this one is constructed from light alloy framing and aluminium panelling. Both the windscreen and the rear light have a considerable wrap-round, and the rear light is electrically demisted by means of heater elements embodied in the glass. All the pillars above the waistline are very slender and add to the graceful appearance, besides increasing the all-round field of vision.

For the garnish rails and cappings, polished figured walnut veneer with cross banding is employed, as it is also for the facia panel, on which the instruments are grouped neatly in front of the driver. This car was awarded the Institute of British Carriage and Automobile Manufacturers' gold medal in the private coachwork section of the competition mentioned earlier.

Park, Ward and Co. Ltd.

Park, Ward has recently built three bodies that are typical of this company's attention both to overall styling and to detail finish. The first of these, a seven-passenger enclosed limousine on a Rolls-Royce Phantom V chassis having a

wheelbase of 144 in, is a good example of a dignified town carriage. Although the body is very spacious, it has a reasonably low silhouette and the high wing styling that is characteristic of these luxurious cars. The model examined was finished externally in black cellulose, with a fine white line and a chromium plated beading along the waistline and on the sill, below the doors. Whereas the front compartment was trimmed in tan leather, light fawn cloth was used in the rear, the headlining and carpet materials being of a similar colour.

The all-steel body structure is of the Park, Ward patented type which, in the main, consists of square-section tubing, shaped to the various contours and welded. It is panelled mainly with aluminium, but aluminium alloy is used for the doors and boot lid. When the doors are closed, each running board—which is of thoroughly practical dimensions—is completely concealed. These running boards are of box construction, with diagonal reinforcement to give stiffness, and provide sound anchorages for the feet of the B and C pillars, which are slim and are attached to the box-section sills. The upper framing of each door is a magnesium alloy casting, and there is a light alloy casting across the scuttle to reinforce the structure in this vital region.

Seating accommodation is arranged for up to seven persons: two are accommodated on the front seat, which is of the divided bench type; the rear seat is wide enough for three occupants, and the remaining two sit on the usual two occasional seats in the rear compartment. Each half of the front seat has two folding armrests, and the driver's half has a slide type adjustment. The occasional seats fold forward against the division when not required. Adjustable foot rests and a nylon fur rug are provided in the rear. The

Above: Interior of the Park, Ward limousine on the Rolls-Royce Phantom V chassis. This body will accommodate seven passengers, two of whom are carried on the folding seats that can be seen in this illustration, and there is a cocktail cabinet on the rear of the division

Interior of the Park, Ward Bentley Continental drophead coupé illustrated on page 555. Padded rolls are fitted along the upper and lower edges of the polished walnut veneered garnish rails on the doors

cushions are built on spring cases that have softer springs in the middle than at the edges. On the springs is a moulded foam rubber overlay which, in the case of the rear seat, is covered with a down filling, resulting in a very high degree of comfort.

The division between the front and rear compartments has a glass, the section of which is curved as viewed in plan, and which is electrically raised or lowered. In the middle of the rear face of the division is a cocktail cabinet, with internal illumination. The cabinet is finished in polished burr walnut veneer, as is the radio loudspeaker mounted beneath it. Below the division window is a broad facia, which is also walnut veneered, but with a cross banded inlay. At floor level on each side of the division is a walnut-faced grille that admits fresh air. Walnut veneer is used also for the facia panel and all the garnish rails on the doors and quarters; the veneers have narrow cross banded inlays. The door windows are electrically operated.

On the offside rear armrest are the controls for the fresh-air inlets just mentioned, together with that for the interior heating. The radio control is on the nearside armrest; the switches for controlling the electric operation of the windows and the division glass are duplicated on the two armrests. Interior heating is of the standard Rolls-Royce type, and in the rear compartment the heated air enters through a grille in the middle of the heelboard.

The equipment and accessories of this car are comprehen-

James Young sedanca de ville with the head retracted. There is only one operating lever, and it is in the middle of the head-rail of the sliding portion of the canopy

sive and include, as part of the interior finishing, everything that could contribute to the comfort of the passengers. In the luggage boot, which has a counterbalanced lid and internal illumination, are two openings covered by flaps, through which access can be obtained to the bulbs of the rear lamp groups. This car most deservedly won a gold medal in the private coachbuilders' section of the I.B.C.A.M. competition, for enclosed drive coachwork fitted with a division.

A Rolls-Royce Silver Cloud II chassis, with a wheelbase of 127 in, forms the basis of the second Park, Ward vehicle, a saloon with a division. This body is a conversion of the standard Rolls-Royce saloon, and incorporates new and wider rear doors and rear quarter lights, as well as being lengthened by 4 in. It is of all-steel, stressed-skin construction and the increased length provides space for the division and more leg room for the rear seat passengers. The lengthening of the body has been cleverly carried out to avoid any break in the continuity of the lines. A chromium plated moulding to the waistline and another at the lower edge of the body play their part in giving a long, sleek appearance.

As on the limousine, the front seat is of the divided bench type, with the driver's portion adjustable fore and aft, and each front door has an adjustable armrest. The rear seat features a central folding armrest. All the seats are based on spring cases, with moulded foam rubber overlays.

Again, the division has a curved glass that is raised and lowered electrically by means of controls on the armrests in the rear seats. In it are folding tables finished with polished burr walnut. The doors, rear quarters, garnish rails and facia panel are very tastefully finished in the same type of timber, but with a lighter cross banding. Carpets and head-lining are in tone with the upholstery, and the rear floor is covered with a lambswool rug. Demisting of the rear light is by the same means as in the Mulliner Bentley.

The third Park, Ward body, a two-door four-seat drophead coupé, is on a Bentley S2 Continental chassis. A somewhat similar model was exhibited at Earls Court in 1959, but the latest version has been restyled to give an impression of greater length and width, and hence of reduced height. The windscreen has more wrap-round than before, and there is a considerable all-round increase in the glass area. A feature of the body is the continuous sweep of the waistline from the headlamp to the rear lamp cluster. The radiator shell has been lowered by 3 in, in comparison with the standard model, and it has also been brought forward at the top.

Welded steel construction is employed for the main portion of the body; this includes the scuttle, floor, rear seat panel and boot floor, with which are incorporated the rear wings and quarter panels. The remaining panels are light alloy and of such a shape that they can be produced on a stretch press. Described as being of anatomical design, the front seats are most comfortable. Each is made up on a light alloy tubular framework, using plastics covered tension springs and a filling of moulded foam rubber. The hammock-like construction is shown in an accompanying illustration. Each squab is adjustable for angle.

The head is raised and lowered electrically and, when down, is stowed in a leather envelope. Polished burr walnut veneer is used for the garnish rails and the facia panel, which is edged top and bottom with padded black leather rolls, for safety and also to prevent reflection of the instruments on the windscreen. There is some Italian influence in the lines of this car, which was awarded a gold medal in Section 3 of the I.B.C.A.M. coachwork competition.

James Young Ltd.

James Young Ltd. has been in the coachbuilding industry since 1863, when the company quickly gained a reputation for high-class products; the traditional skills are still much in evidence today. It is, perhaps, the only privately owned specialist establishment of its type not connected in any way with a vehicle manufacturer. The company has recently produced a sedanca de ville, on a Rolls-Royce Phantom V chassis, which is a superb example of this class of carriage and is equally suitable for the owner-driver or chauffeur. On the example under review, the exterior paintwork was in midnight blue, with a fine gold line to the waist moulding. The trim was in beige leather for the front seats and beige cloth for the rear seat; included in the specification are deep

Park, Ward seven passenger limousine body on the Rolls-Royce Phantom V chassis. Passengers in the rear seats have a wide range of vision through the elongated rear quarter lights

cushions and squabs, pile carpets, and a nylon fur rug on the rear floor.

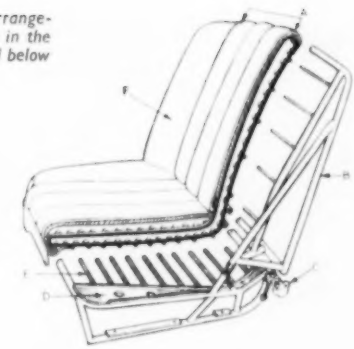
Some six or seven years have elapsed since a body of this type was last shown at Earls Court. It is built of steel and light alloy, with aluminium exterior panelling. The canopy extension is executed in aluminium: the cantrails are housed in a compartment over the rear door and slide out to the extended position, where they are mechanically locked to the screen; the roof panel also locks into place, to form a continuous and robust metal roof. There is only one operating lever, at the middle of the front header rail of the canopy. When closed, the canopy is neatly concealed by a hinged lid in the roof.

The divided bench type front seat has two central folding armrests, and the driver's portion of the seat is adjustable. Three people can be accommodated on the rear seat, which has a folding central armrest providing stowage for gloves and small oddments. The cushions are made up on spring cases, with a foamed latex overlay. In the back of the division are fitted folding tables that have mirror backs, concealing cocktail glasses and clothes brushes. Between the tables is a cabinet containing two decanters, radio loudspeaker, ash tray and clock. All the woodwork of these items is veneered with polished figured walnut, as are the facia panel and the garnish mouldings.

This car is most beautifully finished both inside and out, and looks what it is—an elegant town carriage. It gained the I.B.C.A.M. bronze medal in Section 1. The fact that it did not gain higher placing was not because it was inferior to the others, but because it was competing against a class of cars that were equipped with much bigger enclosed coachwork.

Diagram showing the arrangement of the special seats in the Park, Ward car illustrated below

A *hammock portion;*
B *light alloy frame;*
C *backrest rake adjuster;*
D *light alloy side-roll pan;*
E *plastics covered metal tension spring—the horizontal ties in the squab are elastic tension chords*

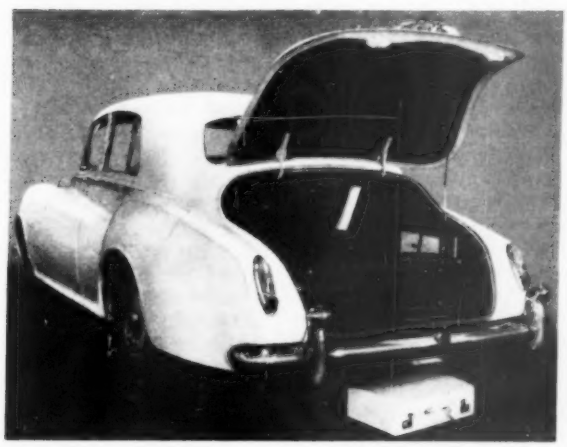


Another good example of James Young craftsmanship is a dignified Rolls-Royce Phantom V seven-passenger limousine. The vehicle exhibited this year at Earls Court was painted black, with a fine gold line and a chromium plated waistline moulding. Its front seats were trimmed with beige hide, whereas beige cloth was used for the rear seats. The body of this limousine is constructed of steel and light alloy, and all the exterior panelling is aluminium.

Housed in the rear face of the division, which is finished in polished figured walnut veneer, are a loudspeaker, an ash tray of ample size and a clock. The division window is electrically operated. In general, the arrangement and upholstery of the seating are similar to those of the sedanca de ville previously described. However, in addition to the front and rear seats, there are the usual two forward-facing occasional seats which are stowed by folding them forward: they are mounted close together so that additional accommodation can be provided for two adults or three children.

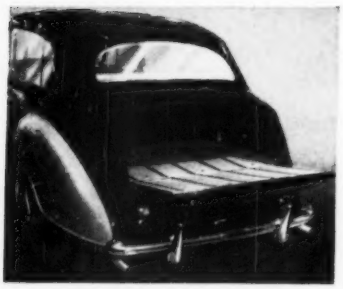
The doors are tastefully trimmed, and are finished with figured walnut garnish rails and cappings. A recessed locker with a sliding shutter is fitted to the bottom of each door and provides ample room for maps or a picnic set. The windows are electrically operated. On this car, too, all the controls for heating, air conditioning and window operations are contained in the rear seat armrests. This limousine gained a silver medal in Section 1 of the I.B.C.A.M. coachwork competition.

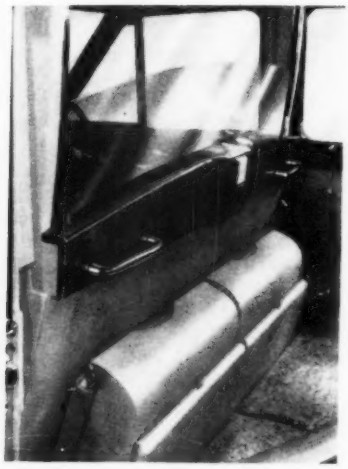
A very good example of a luxurious saloon car is the James Young four-door body mounted on the Rolls-Royce Silver Cloud II long-wheelbase chassis. Noteworthy features are the comfort and roominess, and the impressive appearance resulting from the use of long flowing wing lines in conjunction with razor edge styling of the bodywork; the capacity of the boot is generous. The gracious appearance of the model shown recently at Earls Court was enhanced by the dark green exterior finish, with a fine gold line flanking the



Above: Harold Radford Countryman conversion of the Rolls-Royce Silver Cloud II saloon. In this view, the rear seats are shown folded forward for extra luggage space

Right: Park, Ward Bentley S2 Continental drophead coupé the non-standard light alloy panels of which are designed so that they can be produced on a stretch press





Three views showing details of the Vanden Plas Princess 4 litre limousine. Left: The handle in the middle of the heelboard adjusts both the cushion and the squab. An interesting feature is the running board. Above: The boot lid, when open, will carry extra luggage. Right: Arrangement of the division, with its central clock and ashtray

chromium plated waist moulding. In this moulding are incorporated the exterior handles of the doors and the push buttons of the locks. The trimming is carried out with golden beige leather.

In its construction, the body is essentially the same as the Phantom V models, though the design itself is entirely new. The front seat is of the divided bench type, and tables incorporating mirrors and ash trays are built into the rear of the squabs, which are adjustable for angle. These tables are trimmed and finished in a similar manner to those of the sedanca de ville, except that the polished woodwork is eucalyptus veneer; this is a light golden wood which, though attractive, does not convey so rich an appearance as do the darker timbers, especially against the upholstery colour mentioned. This car was awarded the bronze medal in Section 2 of the I.B.A.C. competition for coachbuilders' bodies on car chassis.

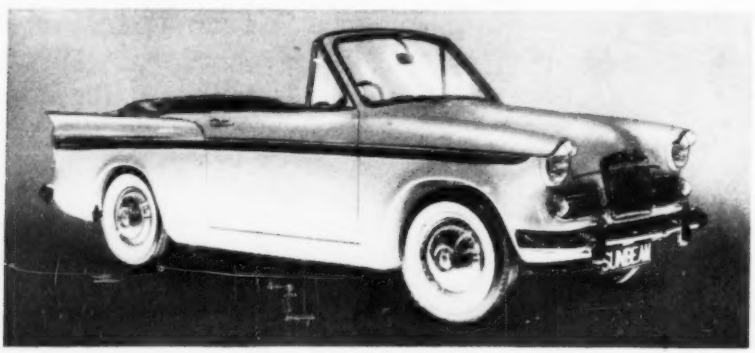
Harold Radford (Coachbuilders) Ltd.

Many interesting features are to be found on the Countryman conversions of the standard Rolls-Royce and Bentley saloons carried out by Harold Radford (Coachbuilders) Ltd. These conversions enable the cars to fulfil various functions such as an owner-driven saloon, a chauffeur-driven limousine, a shooting brake or a luxurious motorized caravan. The Countryman adaptations are certainly unique and ingenious, and a car so converted can be used as a business executive's office, complete with typewriter and tape recorder, where he can wash, shave, eat, drink and even sleep in comfort; the multiplicity of available accessories ranges from an Espresso coffee bar down to a simple waste paper basket.

Perhaps the most impressive Countryman model seen at Earls Court was the Rolls-Royce Silver Cloud II four-door four-light saloon, which was painted off-white with a fine gold line; the seating was trimmed in white leather, and the headlining and carpets were black. The whole vehicle was beautifully finished and provided very comfortable seating accommodation for five people. Individual front seats are fitted, the squabs of which can be set at any angle down to the horizontal. In the back of each squab are an adjustable table and a fitted cocktail cabinet containing the necessary equipment. The squab of the rear seat, which is 4½ in wider than in the standard body, is divided in the middle, and each half can be folded forward and downward to form a luggage carrying platform; when the front seat squabs are lowered, the whole of the seating can be converted to sleeping accommodation. Spring cases with foamed latex overlays are employed for all the seats.

Alterations have been made to the boot lid to give 4 in more internal height than standard, thus substantially increasing the luggage accommodation. The picnic table provided in the boot is robust enough to serve as a grandstand at point-to-point races or other functions. A removable division is supplied for fitting above the squabs of the front seats; when not required it is stowed away in the boot.

For those who like plenty of fresh air, a Webasto folding type of sun roof is fitted. To avoid draughts when this is open, a wind deflector is mounted on the windscreen top rail. Two small round mushroom cushions are provided, for use on picnics; they are accommodated in sockets on top



Among the coachbuilders now manufacturing bodies for quantity produced cars is Thrupp and Maberly, who make this Sunbeam Rapier

of the rear bumper over-riders. Every available cubic inch of space between the outer panels and the linings is used to store the many accessories supplied.

Other coachbuilders

Reference was made in the opening paragraphs to the fact that several firms classified as coachbuilders do not produce specialist coachwork, but either manufacture bodies in quantity for the vehicle builders or adapt standard bodies. Although Vanden Plas (England) Ltd. falls partly in the second category, it now differs from the other companies of the same type in being rated as a car manufacturing organization. Whereas in earlier days the name was associated mainly with sporting and open coachwork, the company now produces the Vanden Plas Princess 3 and 4 litre cars under the aegis of The Austin Motor Co. Ltd. The smaller model is, of course, basically the same as the Austin A99 and Wolseley 6/99 but it has a different front end and is furnished on a really luxurious scale.

It will be recalled that, some years ago, the big Austin Princess was available in either the standard or the Vanden Plas version, the latter having a coachbuilt body. The present 4 litre seven-seat Vanden Plas Princess limousine is a direct descendant of this de luxe version of the Austin Princess and, though it is a normal production vehicle it has much in common with those produced individually. This car has a separate chassis frame, and the body is of composite timber and metal construction. The appearance is dignified and rather staid, and the styling is characterized by a high wing line and a sloping tail.

In the front compartment is a non-adjustable bench type seat, the squab of which embodies a division: in standard form this has a sliding glass panel, but an electrically operated drop glass is available at extra cost. The seat cushion comprises a spring case with a latex foam overlay, and the squab is of moulded latex foam.

Above: In the Harold Radford Countryman conversion of the Rolls-Royce Silver Cloud II, the front seats can each be folded down to make sleeping accommodation for one person. Below: On the Vanden Plas Princess limousine, the front wing line terminates at the rear of the front door

Below: Pressed Steel Co. Ltd. makes bodies for the Jaguar Mark 2 saloons. An interesting detail is the grouping, between facia and transmission tunnel, of the radio and speaker, heater controls and an ashtray

Similar construction is used for the rear seat, but the trimming is West of England cloth. The occasional seats are mounted close together and fold forward against the division. An unusual refinement is that the rear seat cushion and squab have a hinged mounting and are adjustable for angle by a winding mechanism controlled by means of a handle on the heelboard.

The boot lid is hinged at the lower edge and can be used as a carrier for additional luggage; it can support a load of 1 cwt. Since the boot has a capacity of 15 ft^3, it should be amply large for all reasonable requirements. The facia panel, door garnish rails and division are finished in polished walnut veneer. Installed in the rail of the division are a clock and a central ash tray; there is a grab handle at each end.

Of the other coachbuilding firms, Carbodies Ltd. produce a hire car body on the Austin taxi chassis, as well as convertible bodies for the Ford Consul, Zephyr and Zodiac models, and the saloon body for the Daimler Majestic car. For several years, E. D. Abbott Ltd. has specialized in well executed station wagon conversions of the standard Ford Consul, Zephyr and Zodiac bodies. The remaining companies concentrate almost entirely on the production of body shells of various types for the manufacturers of vehicles.

A.G. Roller Lever Lock

Ingenious but Simple Door Lock Intended for Cars of High Quality

MOST of the designs of locks evolved in an endeavour to afford quieter, easier door closing have been both more complex and considerably more expensive to make than orthodox locks. The first of these two disadvantages certainly does not apply to the roller lever lock recently introduced by A.G. Locks, 30 Moss Close, Pinner, Middlesex, as it would be difficult to envisage a simpler mechanism for the purpose. Also, the lock presents no manufacturing difficulties, nor does it require any unusual materials, so production costs should be competitive. In addition to providing quiet, finger-light closing, the A.G. Roller Lever lock also locates the closed door firmly against vertical and transverse movement, so preventing any shake, and it should be at least as safe in the event of an impact as the orthodox type.

The components of the lock, for which patents are pending, are clearly shown in the accompanying illustrations. There are two assemblies, one of which is mounted on the shut pillar and the other on the door pillar. That on the shut pillar comprises a back plate and two horizontally mounted nylon guide blocks, the lower of which has a double-cam profile. At the inboard end of the plate is a flange; to this is stuck a rubber block which, to provide positive tranverse location, is lightly compressed when the door is closed.

Each block is secured to the plate by a cheese-head bolt near each end and a set-screw in the middle. The bolts also serve to retain the plate on the pillar, and their heads are countersunk into the block. In contrast, the screw is fitted from the back of the plate and enters a threaded bush let into the nylon; its head is countersunk into the plate. The purpose of the medial screw is to prevent any bending of the block under load.

It can be seen that the profile of the lower block comprises a curved ramp leading to a recess of approximately semi-circular shape, which blends into a second ramp. Beyond this ramp is a short horizontal portion connecting it to the second recess. These recesses form the half-latch and fully closed locations for the roller, which will be dealt with later. The centres of the arcs of both recesses are $\frac{1}{32}$ in below the level of the top of the block, to prevent the roller from climbing out accidentally. Whereas the leading end of the arc of the first recess is continued to the top of the block, giving a slightly hooked shape, both sides of the second recess are vertical above the level of the arc's centre.

In essence, the assembly attached to the door consists of a back plate, a guide block and two levers, one of which carries the roller and is lightly spring-loaded downward. On the prototypes examined, Duralumin SP30 material is used for the guide blocks, because of its good frictional and wear characteristics in contact with nylon. The roller and this guide block, which slides with small vertical and end clearances between the two on the pillar, are on the exposed side of the back plate, near its upper edge, whereas the lever mechanism is enclosed within the door. Two cheese-head bolts, similar to those already mentioned, pass through the block and the plate to attach the unit to the door pillar; an additional countersunk screw secures only the plate to the door. The block has a cut-out in its lower edge, near the inboard end, to provide operating clearance for the roller.

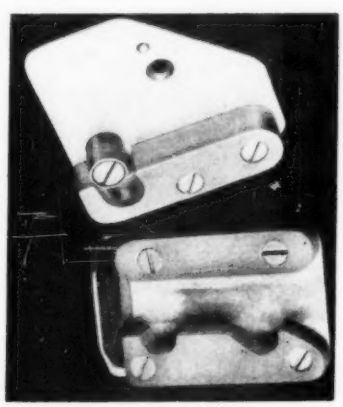
A hardened steel bush floats in the hole in the fulcrum end of the mild steel lever that carries the roller. This bush fits over a stud, the shank of which is pressed into the back plate and is secured by riveting. The lever is retained on the stud by a plain washer and a nut; since the bush is slightly longer than the thickness of the lever, it is trapped by the washer when the nut is tightened.

The brass roller is mounted at the other end of the lever and has a similar bearing arrangement. It runs on a hardened steel bush, which is trapped between the lever and the cheese head of the pivot bolt passing through it. Since the lever is on one side of the back plate and the roller is on the other, the plate has an arcuate clearance slot through which the bush passes. The roller is retained on the bush by the bolt head. On production versions of the lock, stiff-nuts will be fitted to the fulcrum stud and the roller pivot bolt in place of castellated nuts, one of which can be seen in the illustration opposite.

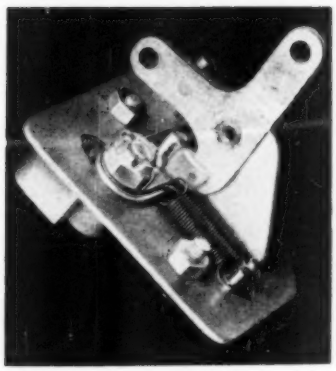
A detail of interest is that, when the roller registers in either of the recesses, the lever is inclined upward from the fulcrum end. Any tendency of the door to move open under lateral loads, therefore, results in a small downward force on the roller, tending to keep it engaged. In this respect, of course, the weight of the lever assembly and the spring loading, which is provided by two light tension springs, also help to keep the roller in engagement.

The duplication of the springs is purely a safety measure, since the lock engages perfectly when only one is fitted. At their lower ends, the springs are anchored by small pegs riveted to the back plate, and their upper loops encircle a piece of steel wire formed in roughly the shape of a letter J with an incomplete bar. The half-bar of the J makes an acute angle with the shank and is pushed into a correspondingly inclined hole drilled in the lower edge of the lever, near the roller mounting; the curved portion of the wire is then sprung on to the semicircular end of the lever, which has a shallow peripheral groove to locate it.

Pressed into a hole in the lever, at rather more than half-length from the fulcrum, is the hardened steel actuating peg. Against this peg bears a nylon thrust pad attached to one arm of the second lever, which is of T shape. The other arm and the leg of the T are connected to the external push button and internal handle of the door. This lever is made



The upper of the two assemblies is mounted on the door pillar of the car; it carries a roller that registers in the recesses in the lower guide block of the second assembly



This view reveals the simple mechanism of the door-mounted unit. The lever carrying the roller is actuated by a second lever, of T shape, on to which is riveted a thrust pad of nylon

in two parts, riveted together; by virtue of the two-piece construction, the lever straddles its pivot bracket and so is well supported.

It can be seen from one illustration that the bracket, which is riveted to the back plate, need not be at right angles thereto, as it is on the prototypes. There is no difficulty in mounting it at any convenient angle, and the actuating lever could even be parallel to the plate, if desirable for any particular installation. The working face of the nylon thrust pad has a double curvature, to avoid local wear owing to point contact on the peg.

The inventor of this lock, W. R. Vane, has fitted an example to a car, and from an inspection of this installation it appeared that his claims are well justified. If the door was closed until the roller touched the first ramp, only finger pressure was necessary to shut it positively. The only noticeable resistance, in fact, was that necessary for slight compression of the rubber stop, to enable the roller to drop into its second recess. In addition, the door was securely held in the closed position, and the handle action to open it was remarkably light.

Other points in favour of this design include the generally low rate of wear without lubrication, owing to the use of nylon and hardened bushes, and the fact that the springs are only lightly loaded when the door is shut. A more robust bearing for the actuating lever might prove to be desirable, however, particularly if oblique loadings were applied to it by the handle and push-button linkages. Such a modification could readily be embodied, of course, without appreciably complicating the simple basic design.

Pioneers of Petrol

NOWADAYS, it is probably not generally appreciated that the name "petrol" came into being not as a general term but as a trade name. In 1859, the firm that was later to become Carless, Capel and Leonard was founded in Hackney, then a hamlet to the east of London. Its business was the production of mineral oils and fuels of various sorts, mainly from bituminous shales, and well before the end of the century, the company was importing and refining American crude oil.

Early in the 1890s, F. R. Simms, a friend and business associate of Gottlieb Daimler, approached Carless, Capel and Leonard for supplies of high-volatility fuel for the Daimler internal combustion engines he was importing. The company was able to meet this request, and its product was originally referred to as "Deodorized Petroleum Spirit, S.G. 0.680". Early in 1893, it was decided to give this fuel a distinctive name. Simms suggested "Petrol" but the company at first objected on the grounds that the word was too like petroleum, then a trade name for paraffin oil.

Simms soon overcame the objection and the term was duly adopted. It was officially used for the first time in a pamphlet prepared by the company to publicize the new fuel. Although the name could not be registered as a trade mark, because it was a descriptive word, Leonard was at that time able to persuade his competitors to call their motor spirits by other names.

Anti-Corrosion Measures

RECENT emphasis in Great Britain and Europe on the provision of improved corrosion resistance in unitary body structures is paralleled in the U.S.A. by processes introduced for the new compact cars. The Chrysler Corporation is using a seven-stage dip system for the Valiant, and also for the unitary bodies of their 1960 larger cars. In the under-body portion of the Chevrolet Corvair, the more corrosionally critical panels are, of course, of a heavier gauge of steel than that employed elsewhere. Some of the panels are sprayed with a zinc-rich primer, which does not inhibit welding after the pressing operations. In addition, a wax-base coating is applied to certain areas after welding.

Galvanized sheet is used by Ford for the under-body panelling of the Falcon. Previous attempts to spot weld zinc coated sheet failed because of the build-up of zinc oxide on the copper electrodes; cleaning of the electrodes was required too frequently for economy of production. This difficulty has been overcome by wiping off about two-thirds of the coating from one side of the sheet, during the dipping process. Since the thinner coating is on the outside, where the welding takes place, the rate of oxide build-up on the electrodes is reduced sufficiently for cleaning to be unnecessary during shifts.

Battery Charging System

IN THE March 1960 issue of *Automobile Engineer*, reference was made to the Catylator battery cap, which reduces topping-up frequency and eliminates the risk of corrosion or explosions through gassing. Details have since been received of an interesting system of battery charging based on the use of Catylators. Known as Cyclocat, this system has been evolved by Harmer and Simmons Ltd, an associate company of Catylators Ltd. The purpose of the system is to effect charging as quickly as possible, while avoiding excessive gassing or overheating of the electrolyte.

For its control of the charging rate, the Cyclocat charger depends on the fact that, when the gases given off by the battery are recombined to water in the Catylator, heat is generated, in direct proportion to the rate of conversion. Further, as a result of convection, the temperature of the Catylator is affected by that of the electrolyte. The variations in charging rate necessary to prevent over-gassing or excessive temperature rise of the electrolyte are made through the agency of a temperature-sensitive device in contact with one of the Catylators. Before the cell voltage reaches the level at which gassing occurs, the charging current is, of course, dependent on the characteristics of the battery and the maximum output of the charger. Further particulars of the Cyclocat method are available from Harmer and Simmons Ltd, Roebuck Road, Hainault, Essex.

The Citroën Bijou

A Reinforced Plastics Body, Designed and Made in Britain, on the Well-proved 2 CV Chassis. The Bijou is a Small, Fully Equipped Car of Unusual Characteristics

FEATURING the simplest possible four-seater body on a chassis of unusual design, the Citroën 2 CV saloon, fully described in earlier issues,* has over the years built up a reputation for toughness and reliability throughout the world. Its horizontally-opposed, twin-cylinder, air-cooled engine of 425 cm³ swept volume and rated at only 12 b.h.p. is designed for long life rather for high performance. The reputation stems largely from the unique suspension system which, by a combination of long wheel travel and interaction between the front and rear wheels on each side, gives the vehicle a remarkable off-the-road performance. Each wheel is mounted independently on a swinging arm, leading at the front and trailing at the rear, while interacting helical springs mounted longitudinally at each side of the chassis frame control the wheels on that side. Bump deflection of a front wheel compresses both springs by means of a pull-rod, and has the effect of stiffening the suspension of the following wheel to meet the bump. A simple, dynamic shock absorber is provided at each wheel axle. The arrangement is so designed and phased that the vehicle can be driven fast over rough country, or even ploughed fields.

Notwithstanding the practical merit of the chassis, the austerity of the body and the price, inflated by import duty and purchase tax, have tended to limit the appeal of the vehicle in Britain. Citroën Cars Ltd, at Slough, considered, therefore, how the ingenious chassis could be utilized in a more attractive guise. Rather than attempt to compete with well established, mass-produced, family cars, it was decided to produce a vehicle to appeal to a narrower but more discriminating market. In particular, there was thought to be a market for a small, high-quality, long-lasting vehicle as a second car in families already owning a larger car. Used for shopping and local motoring, such a vehicle would not need full family accommodation nor high power. It should require only a minimum of maintenance and attention and be capable of resisting deterioration without the protection of a second garage. In both these aspects the air-cooled engine and the simple chassis design are advantageous. The problem of outdoor storage could be met by the use of a non-rusting, non-corrodible body.

Polyester-glass body

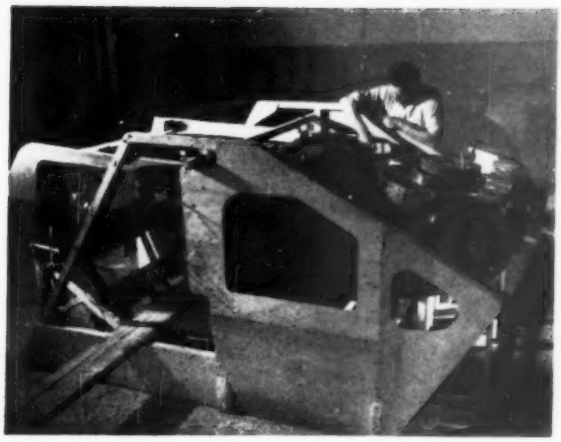
It was decided to produce a body of the occasional four-seater type in glass fibre-reinforced polyester resin. This material has the further advantage that attractive lines could be obtained without incurring the heavy tooling investment required for the production of metal panels, which could be justified only by large-scale output. As will be seen in the illustration, the design finally selected has with some success adapted the characteristic body lines of the larger Citroën cars to the small vehicle. The overall dimensions are given on the drawing.

Production of the body was entrusted to James Whitson and Co. Ltd, of Yiewsley, Middlesex, a coachbuilding firm that took up plastics fabrication in its early days and have a successful record in the production of coach and commercial vehicle bodies and cabs. Additionally, they have

* "*Automobile Engineer*", March and May 1954.

Above: The Citroën 2 CV has a very simple four-seat body mounted on a robust chassis having exceptional ability to cope with poor roads. The engine is an air-cooled, overhead-valve, horizontally-opposed unit of only 425 cm³ swept volume

Left: The British designed and built Bijou, with a low-drag body of glass-fibre-reinforced polyester resin, is produced as a small, "second" car that needs no garage



Strength, alignment and interchangeability of units is ensured by bonding components of the body in a stout jig. Here, the floor section is being bonded to the centre shell by means of strips of glass mat and resin

built a number of car bodies and currently are engaged in the production of bodies for the new Warwick car. This firm undertook responsibility for detailing the Bijou design for production. Every effort was made to take advantage of moulding techniques to simplify production of the body and to fit it to the existing chassis with a minimum of modification. From the start it was borne in mind that the exceptional riding qualities and strength of the chassis would demand unusual stability from the shell in order to withstand the loads involved in fast travel over rough ground.

Stiffness has been achieved with a minimum of metal reinforcement by ensuring that loads are adequately spread and by using the minimum number of separate parts. A complete body shell, consists of only eleven separate mouldings. The largest component is the centre shell, comprising roof, pillars, scuttle, floor beams, rear quarters and tail. To this is bonded the floor panel, including boot floor and spare wheel carrier, the two rectangular mouldings which form box members and pockets beside the rear seat, and the dash panel. Doors, boot lid, bonnet, and wheel arches are the only separate components.

Rapid development

An important advantage of the use of reinforced resin construction was the speed with which production tooling could be completed. The decision to proceed with the design was taken only in June of 1959, and a prototype car was prepared in time for the Motor Show of that year, by which time production moulds were well under way. After only about 18 months, with a comprehensive programme of development testing behind them cars are reaching the dealers in considerable numbers. At present, production capacity is arranged for 30 complete bodies per week.

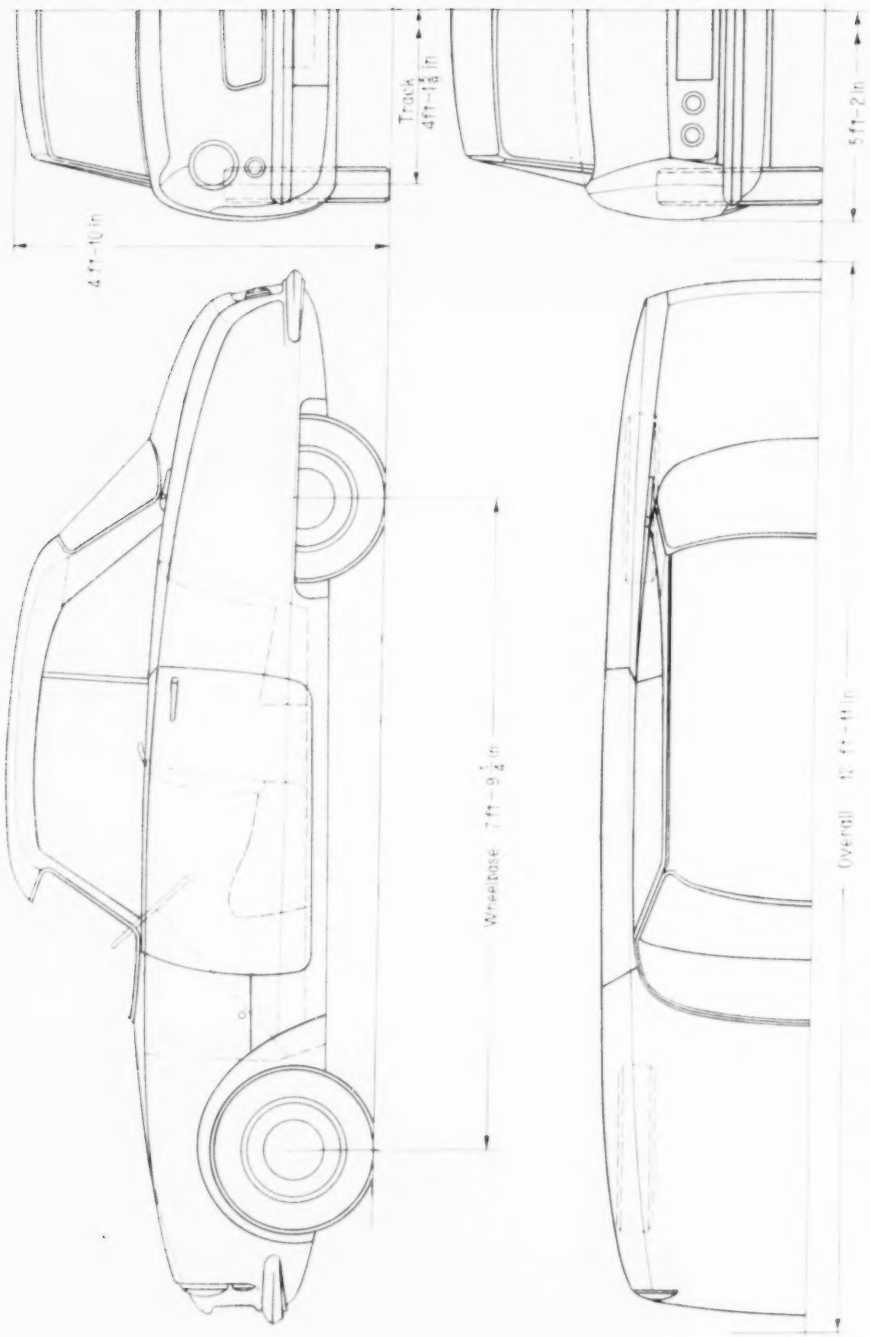
Conventional wet lay-up moulding technique is used, but particular attention has been paid to the construction of the moulds, which are heavy and well-braced reinforced resin structures. The resins used for the body are by British Resin Products Ltd, and Artrite Resins Ltd. An Artrite resin of special formulation is used exclusively for mould construction, since it has been found that it produces a very hard and tough surface that is highly resistant to pick-up by resin during moulding operations. To obtain the longest possible useful life from the moulds, they are thoroughly washed and dried after every cycle, re-waxed and treated with a polyvinyl alchohol parting agent.

The main body shell is built up of two layers of chopped-strand glass mat, each weighing 1½ oz/ft². Three layers are used for the more highly stressed doors and body rear quarters; one of the advantages of this form of construction being the ease with which local reinforcement can be provided by increasing the thickness of the skin wherever required. The work of laying up is much simplified by the use of fully-formulated resins, which require no preparation by the user apart from the addition of the hardener just prior to moulding. The Artrite resin Type L.U. 102, for example, incorporates fire-retardant additives which, together with matched pigments, accelerator, thixotropic agent, and other components, are mixed under laboratory control. This relieves the user of the responsibility of dispensing the precise quantities of the correct materials and blending them into an appropriate mix. It also ensures that complete consistency is obtained from batch to batch; an important factor as regards the quality control of the end product.

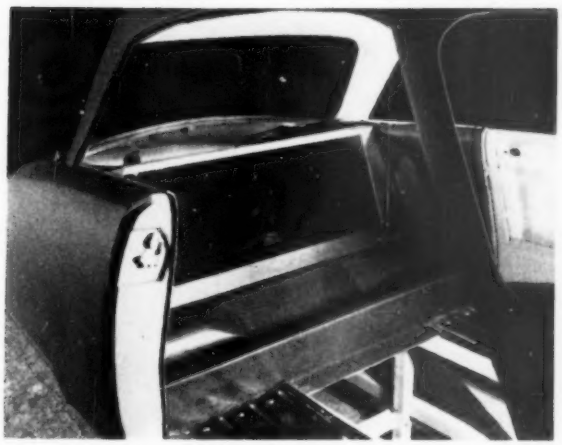
Curing

Large mouldings are left overnight to cure in the shop, which is maintained at a temperature of about 70 deg F. Smaller parts are placed in a "hot room", held at a temperature of about 120 deg F, to accelerate curing and to develop maximum physical properties. It is planned, as production builds up, to arrange for accelerated curing of all components, in order to raise the rate of mould utilization from once to twice per day and thus to reduce overhead costs.

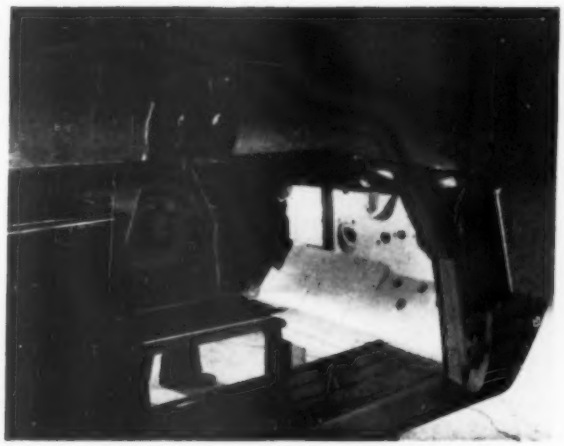
Only eleven separate mouldings make up the complete body, the largest being the centre unit embodying roof, scuttle, side members and rear quarters. The floor, dash panel and map pockets are bonded to the main structure



Outline drawing of the Bijou low-drag bodywork, showing main dimensions. Fabricated in glass fibre-reinforced plastics material, the body is specifically designed to withstand life-long exposure to the elements



Rear interior of body, showing the floor pan in place, and one of the pockets which stiffen the rear quarters. The floor space on either side of the chassis platform is bridged by a sheet steel panel, riveted in position



Very little steel reinforcement is required; stiffness is obtained by deep curvature. Steel channels strengthen the door-shut pillars, while triangular panels brace the scuttle and bonnet mountings at each side

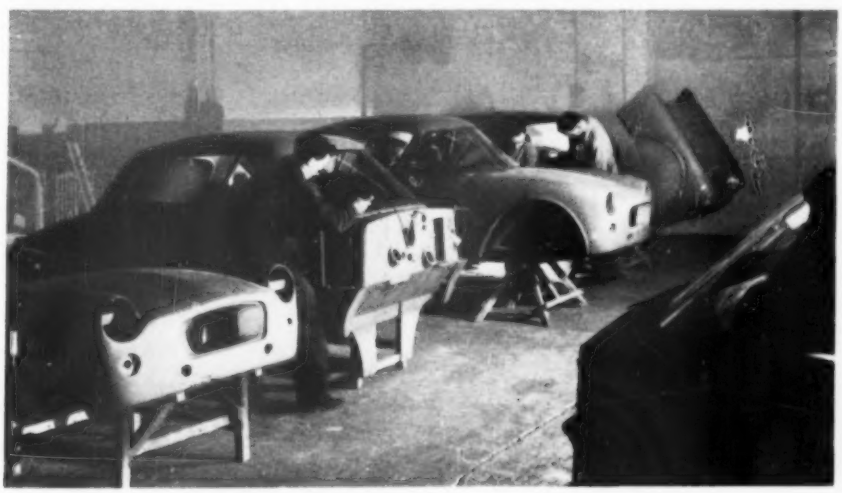
Body assembly

One of the most critical operations in the whole production cycle is the bonding of the various sub-assemblies into the composite shell. To ensure accurate alignment, full strength of bond and interchangeability of components on final assembly, a sturdy jig is used. On this, the upper part of the body shell and the floor panel are rigidly aligned and clamped while glass mat and resin are applied to the joint lines. The assembly is left in the jig until cure is complete, to eliminate any possibility of distortion. In practice, any moulding from any of the six production moulds at present in use, can be matched with any mating component from any other mould.

The major sub-assemblies are built up into complete bodies on the production line. Timber assembly platforms are used, final alignment of the bonnet and the chassis mounting points being carried out on a production chassis, one of which may be seen in the illustration of this line. The chassis has a central sheet steel platform, the spaces on either side being filled in by steel panels riveted to the body shell, as shown in the interior rear view. This view also gives some idea of the way in which strength and rigidity have been assured by the use of deep sections and double curvature. One of the rear seat pockets can be seen in position, where it forms a strong box structure at the rear quarter. The only metal structural member in the rear of the body is the light-gauge, angle section, tie bar connecting the two sides and forming a support for the rear seat squab and the parcel shelf. It is arranged for the squab to fold forward, thereby enlarging the capacity of the boot.

Other metal components are to be seen in the interior front view. A length of $\frac{1}{2}$ in diameter, 16-gauge, steel tube is inserted in each windscreen pillar and carried down to floor level, while 16-gauge channel sections are bonded in to stiffen the door-shut pillars. The 14-gauge triangular insert in front of the door pillar, stiffens the scuttle assembly and locates the bonnet-lock spigots. This sparing use of metal reinforcing elements is largely due to the ingenious manner in which very deep channels have been moulded into the panel edges. Door flanges, for instance, are about $\frac{1}{2}$ in thick, and about 1 in deep, yet they are hollow-moulded. To achieve completely satisfactory penetration of glass-fibre and resin into such deep and relatively inaccessible sections may be reckoned an achievement. The result, in the case of the large doors, is a very creditable rigidity.

Weighing only 167 lb each, the complete body shells are given a coat of primer and delivered to Slough for final finishing and trimming. Mouldings are not impregnated with a finish colour, as is sometimes done, but a high quality coach finish is applied later at the Citroën works. It may



Part of the body assembly line at J. Whitson and Co. Ltd, who are producing the body shells. Accurate alignment is assured by building up the assembly on the production chassis in the background

be noted that the general finish of these cars is of an exceptional quality for reinforced resin bodywork, due largely to the care that is taken with the preparation of the moulds.

Final assembly

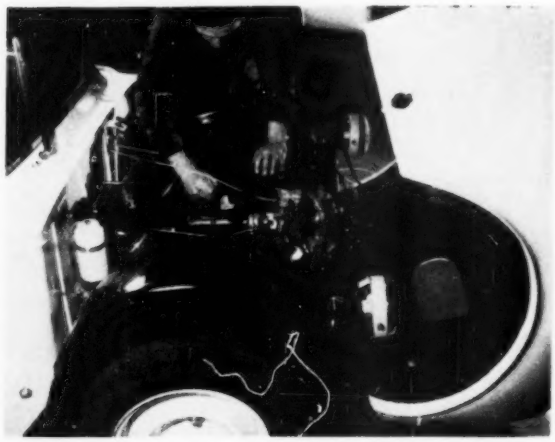
Part of the final assembly line at Slough is illustrated. In the foreground is a 2 CV chassis complete with engine; features of the unusual suspension system are clearly shown. The body shell, lowered from an overhead conveyor, is mounted at only four main points on the outriggers from the chassis frame side members. Four bolts in each outrigger hold the body, which elsewhere is insulated from the chassis by rubber strips surrounding the floor panel. At the tail end, the body is further located on a steady support at the rear of the chassis, while the bonnet is hinged across the front of the chassis, so that it can be swung forward to give access to the entire engine and transmission unit, as illustrated. The wheel arches are bolted to the chassis and to the lower part of the scuttle.

An unusual feature, shown in this illustration, is the method of headlamp mounting. The angular setting of the lamps can be adjusted from the interior of the car, as on the original 2 CV model. They are mounted on a tubular cross-member, and tilted up or down by means of a steel rod controlled from the driver's seat. This facility is rendered necessary by the soft, long-travel suspension system, which results in considerable change of attitude between lightly and heavily laden vehicle conditions. The lamp apertures in the bonnet allow sufficient clearance for this movement yet, by careful design of the recessed apertures, the lamps have the appearance of being conventionally mounted.

Since the weatherproof properties of the moulded body, and the freedom from the frost hazard conferred by the use of an air-cooled engine, will tend to encourage outdoor storage of the Bijou, other commonly vulnerable items have been designed to withstand the practice. Bumpers are of polished light alloy and the door handles of stainless steel.

Performance

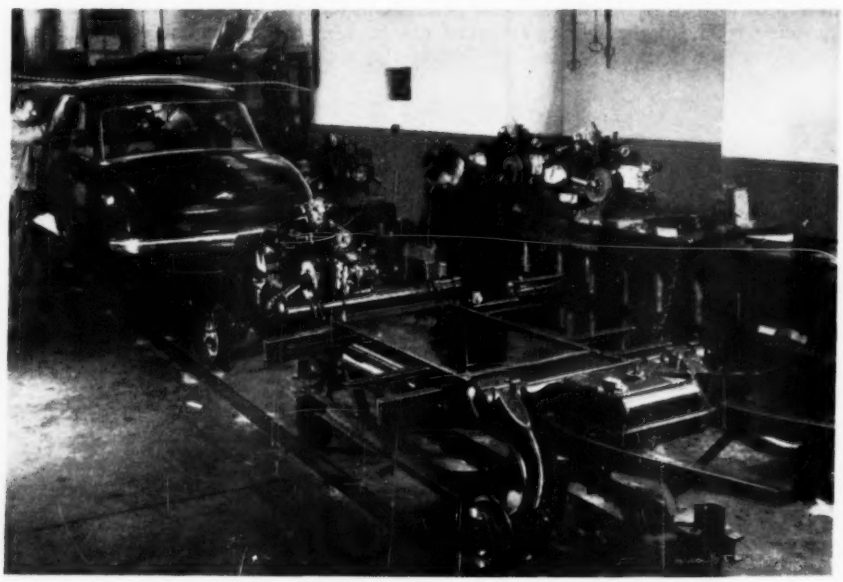
Before deliveries commenced, the Bijou was subjected to unusually rigorous tests for a vehicle of this class. One of the most severe trials entailed prolonged driving at speed over the M.I.R.A. test pavé. On this destructive stretch of road it was possible for a passenger to read a newspaper while travelling at 30 mile/hr. More important, the body proved its ability to withstand this harsh treatment.



The bonnet swings forward on front hinges to give access to the engine and transmission. The 2 CV lamp-mounting system is retained, with driver control of angle for adjustment to suit variations in vehicle loading

On poor road surfaces there is little noise inside the body, from either road rumble or suspension movement. This is largely attributable to the sound-deadening and non-resonant properties of the reinforced plastics body. The performance and economy of the new car are superior to those of the original 2 CV model, due to the exceptionally low drag coefficient of the body form. Approximate figures for top speed and petrol consumption are 55 mile/hr and up to 60 mile/gal respectively. The consumption rate quoted was attained during full-throttle runs on the M1 motorway.

Although the new car is not intended to match the speed of popular family cars, it is quite capable of maintaining its place in a main road traffic stream. Its reliability, economy, comfortable ride, off-the-road performance, full equipment of good quality, and simple maintenance make it an attractive and practical vehicle for its intended purpose. It is unusual in being specifically designed, from its inception, to withstand storage in the open, exposed to the elements.



Complete body shells are mounted on the chassis at the Citroën works at Slough. The body is carried on four chassis outriggers and secured at each by four bolts. Rubber strips insulate the body from the chassis

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Designers
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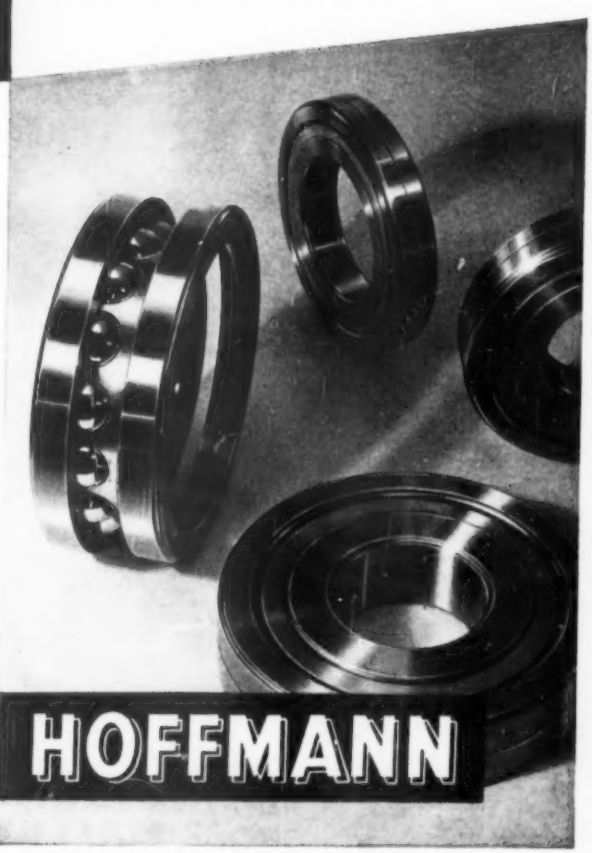

The Duplex Bearing No. 4

The forerunner of this bearing was the fifty-years-old Hoffmann four-point contact bearing. The likeness will be seen by comparing the sketches below.

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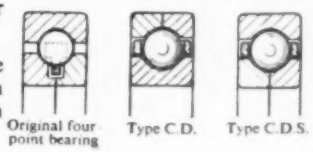

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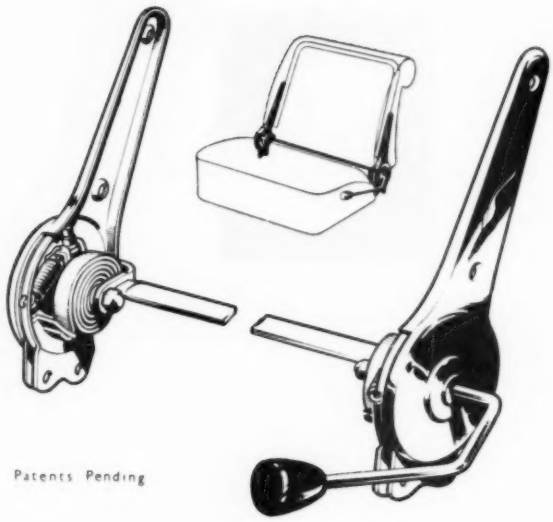
The seat squab is spring loaded—lifting the squab from the horizontal.



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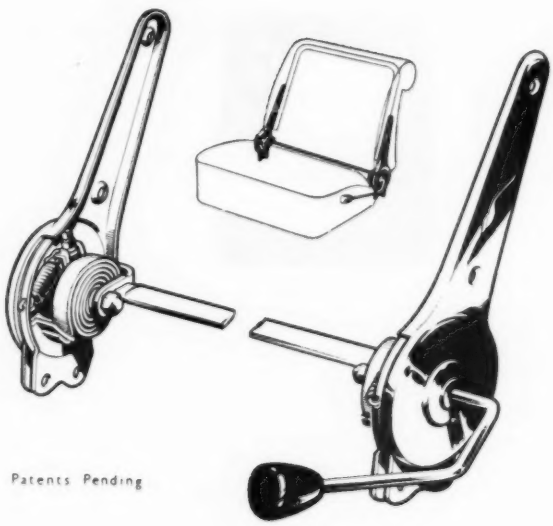

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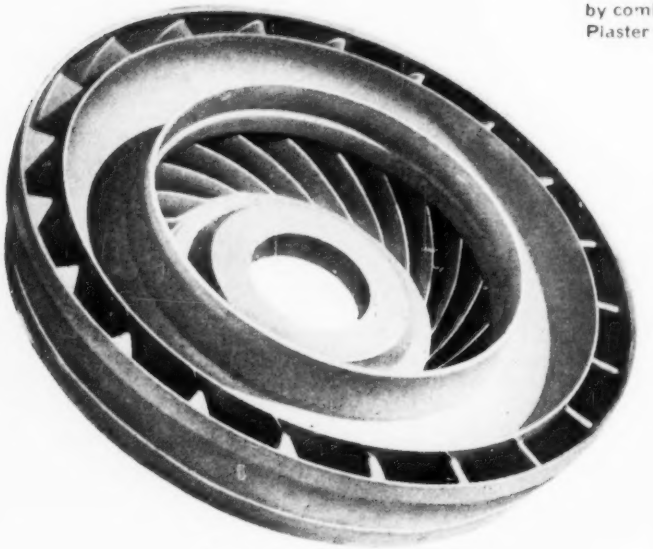

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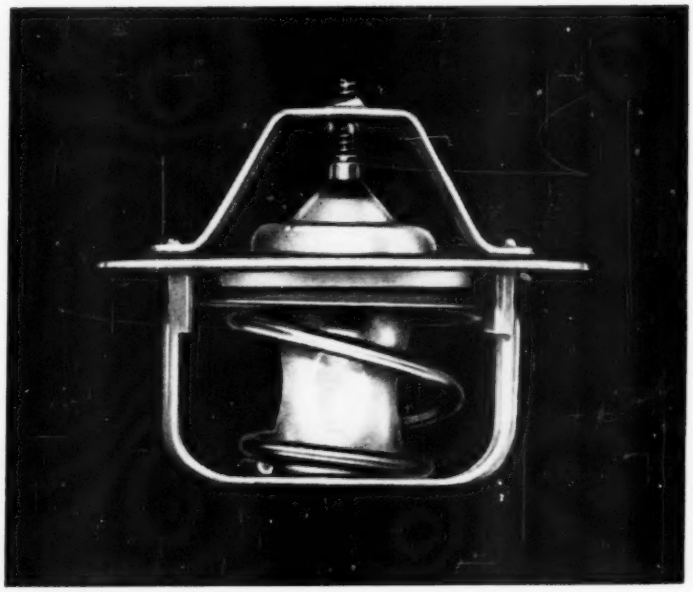

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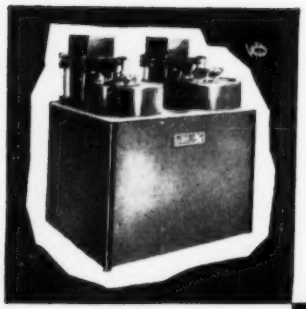

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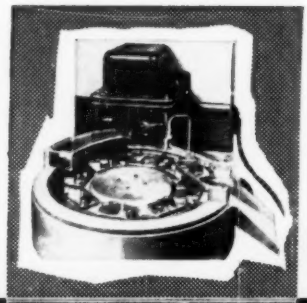
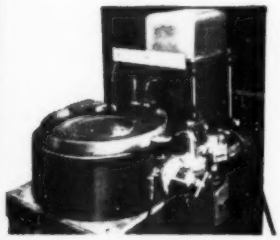
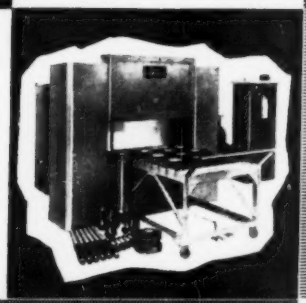
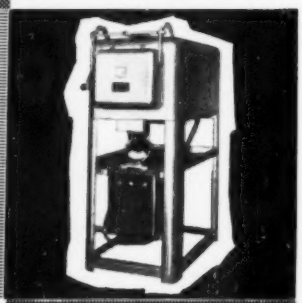
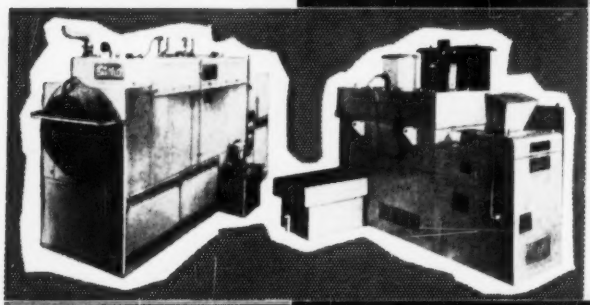




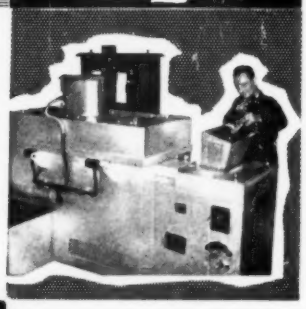
GENERAL PURPOSE FURNACES

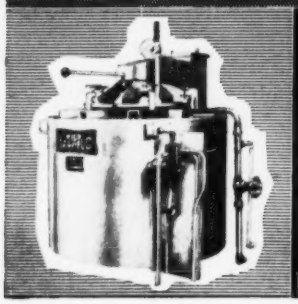


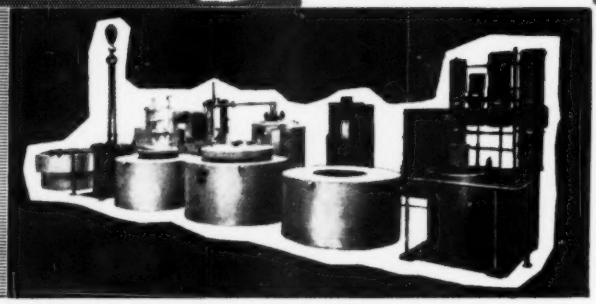




CONTINUOUS CARBO-NITRIDING FURNACES







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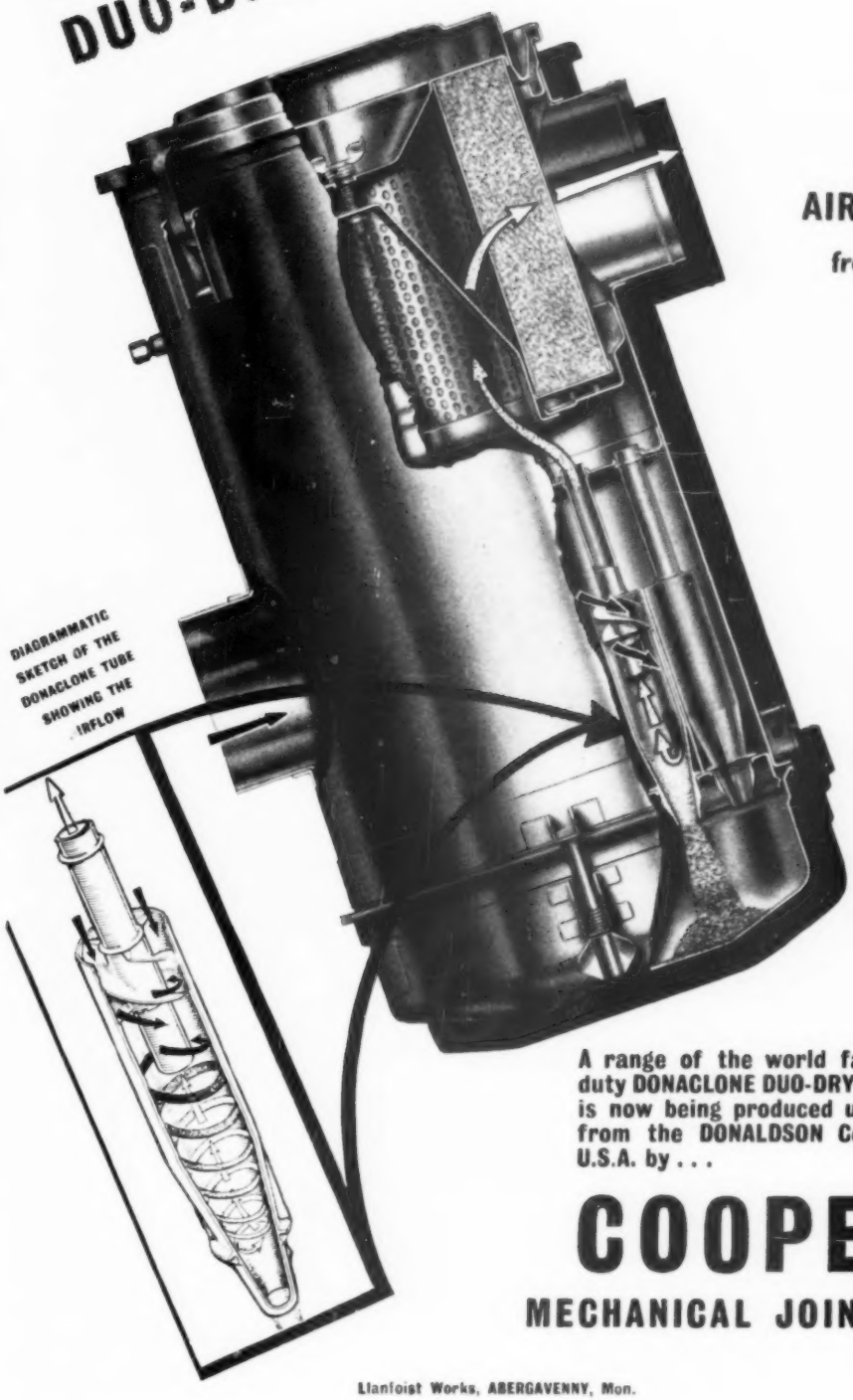

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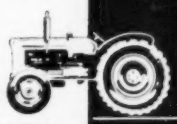

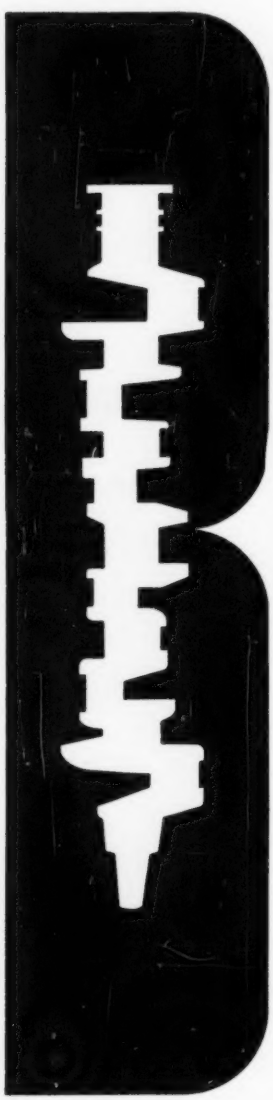

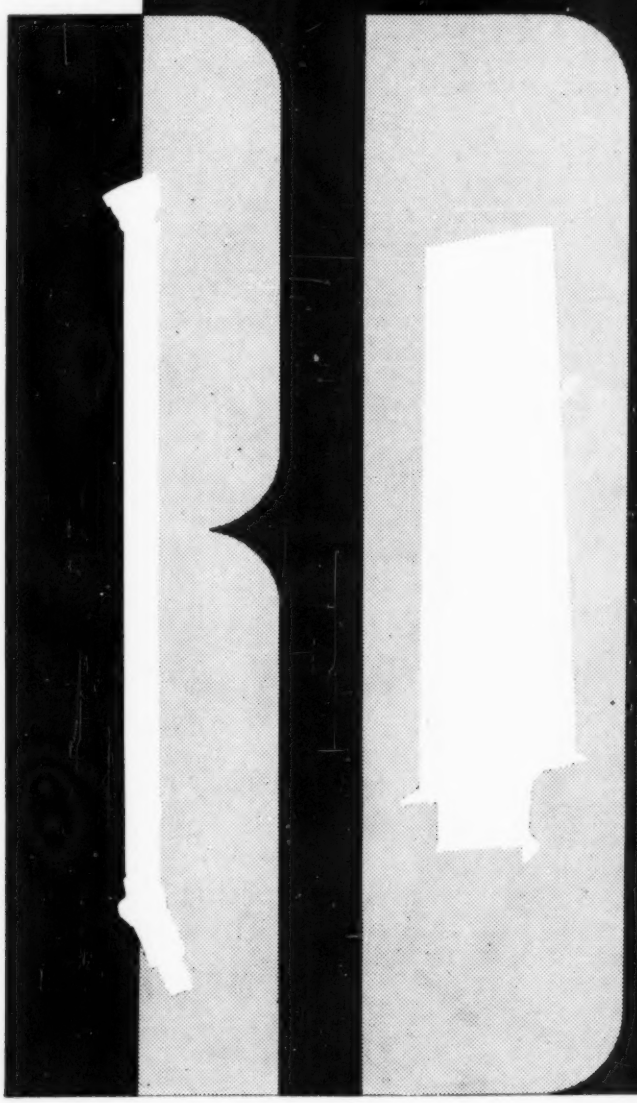

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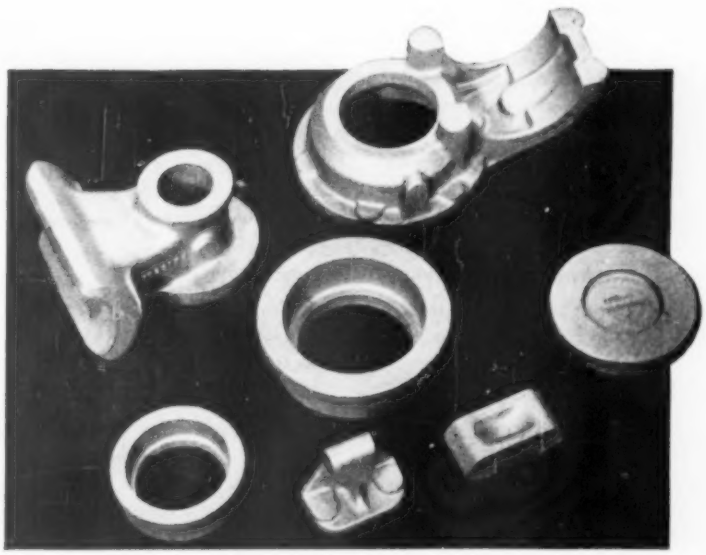

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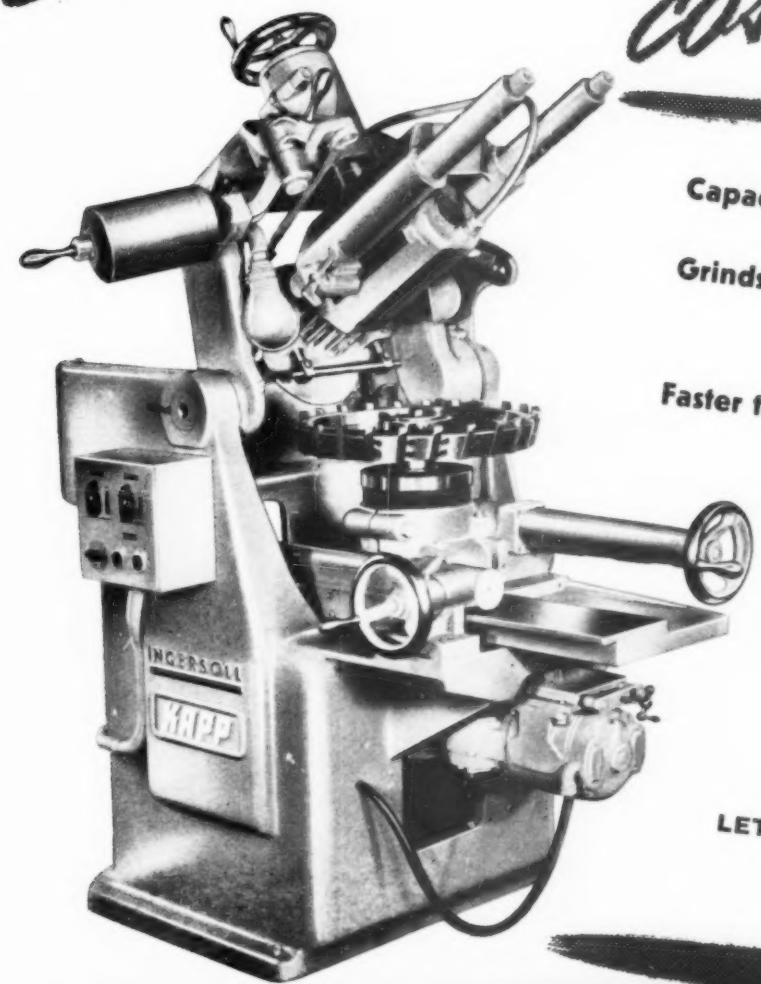

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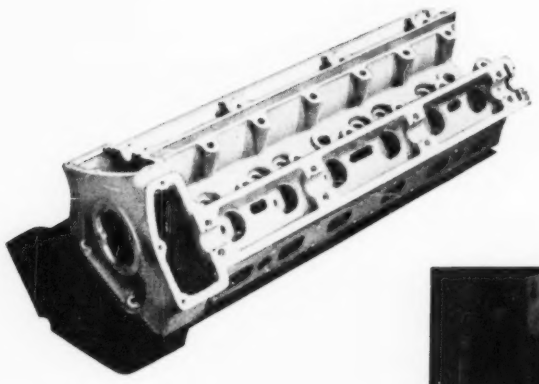
On with her head!



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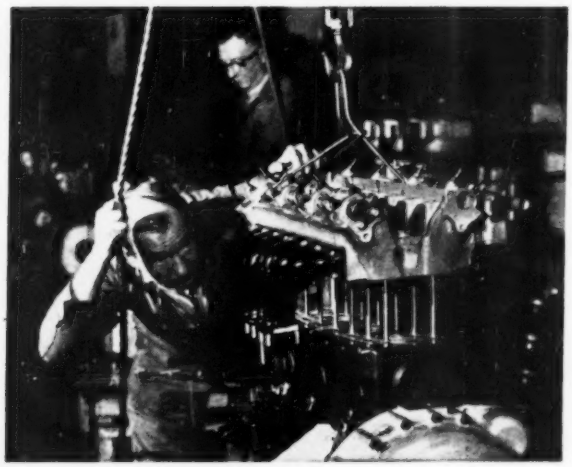

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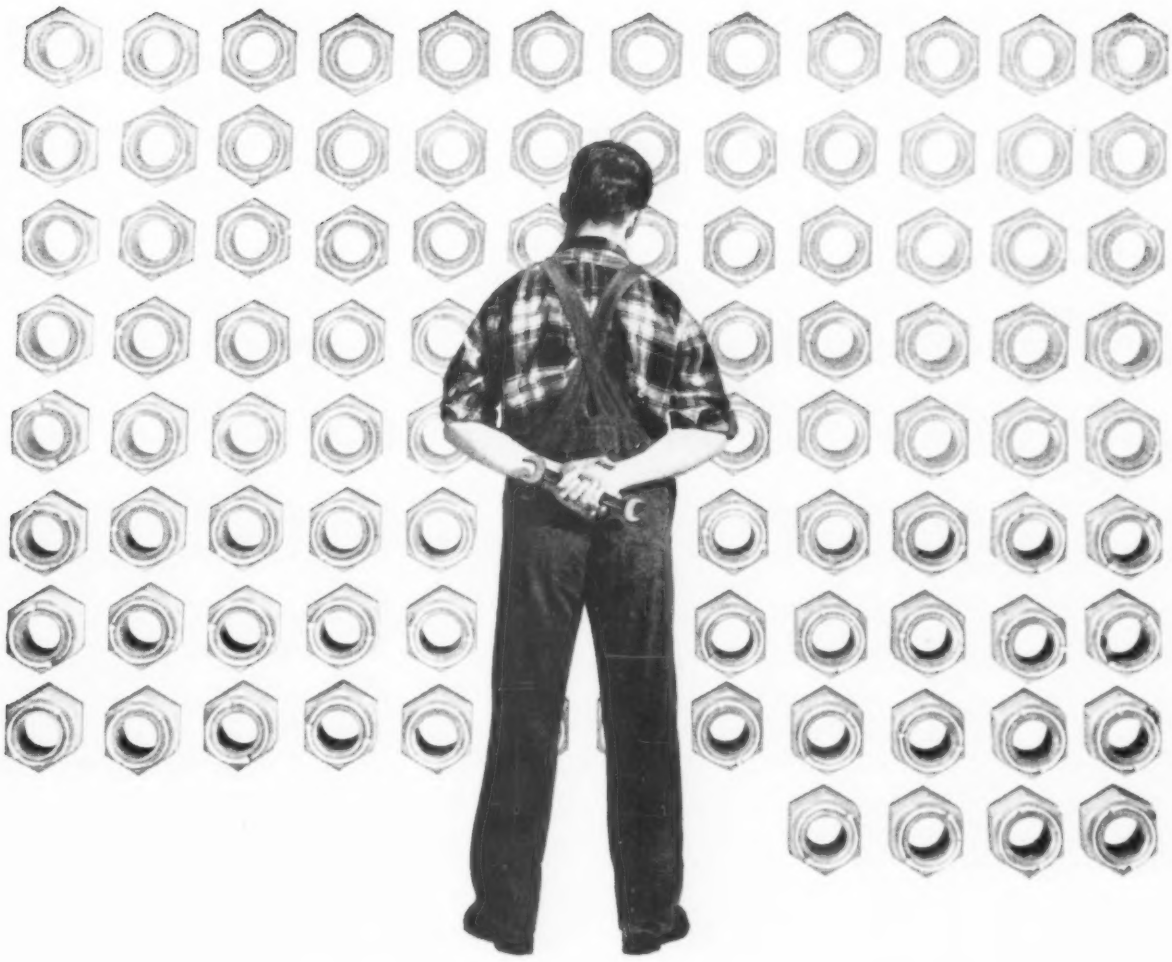

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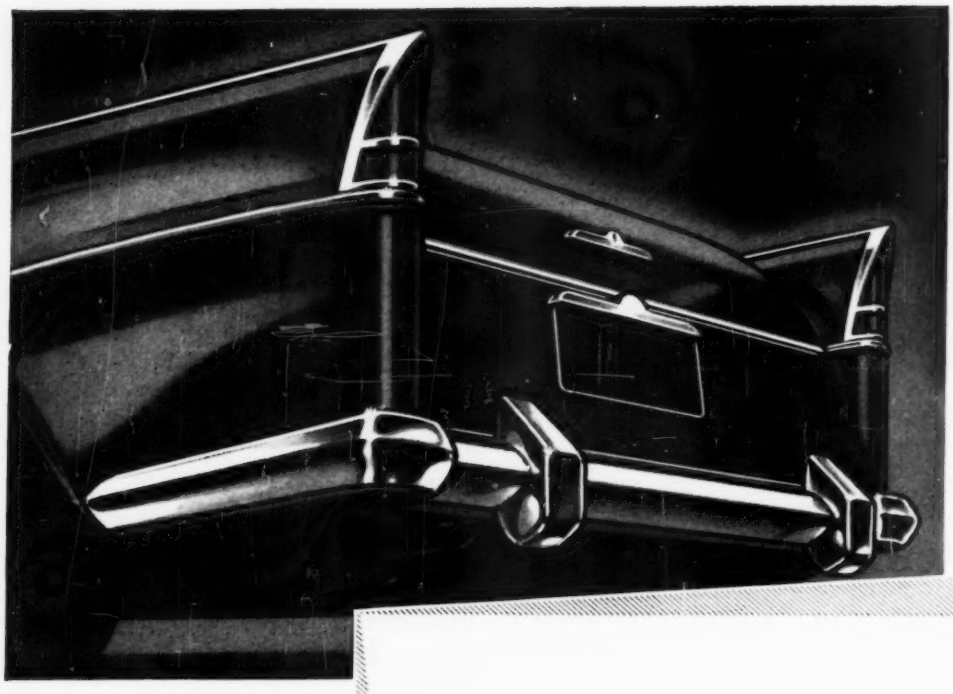

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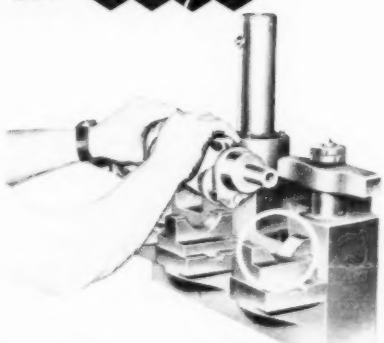

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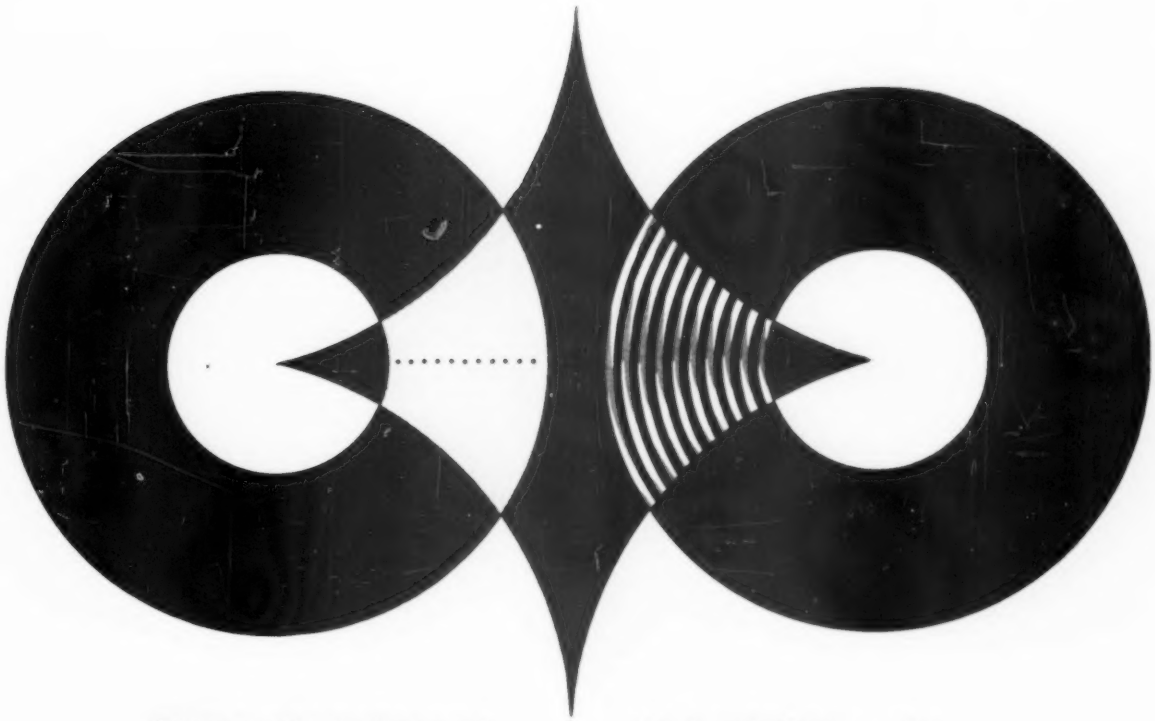
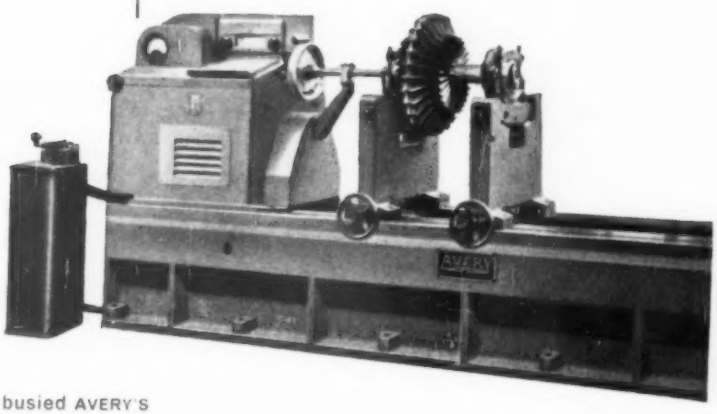


Static, it's balanced but rotating . . .?



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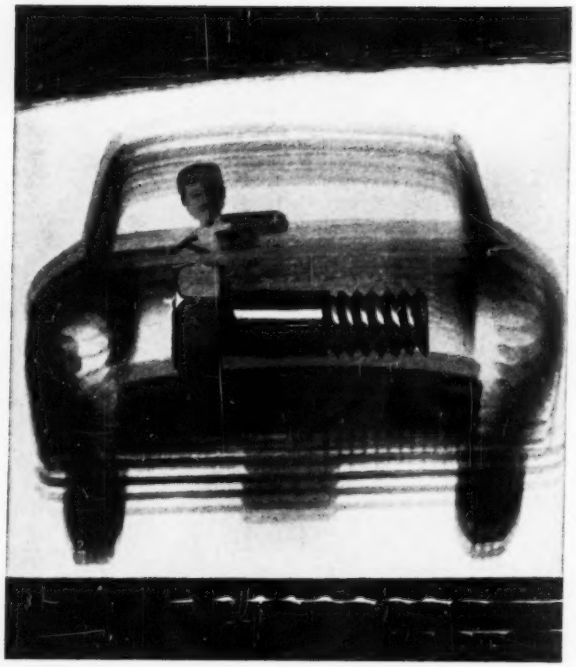

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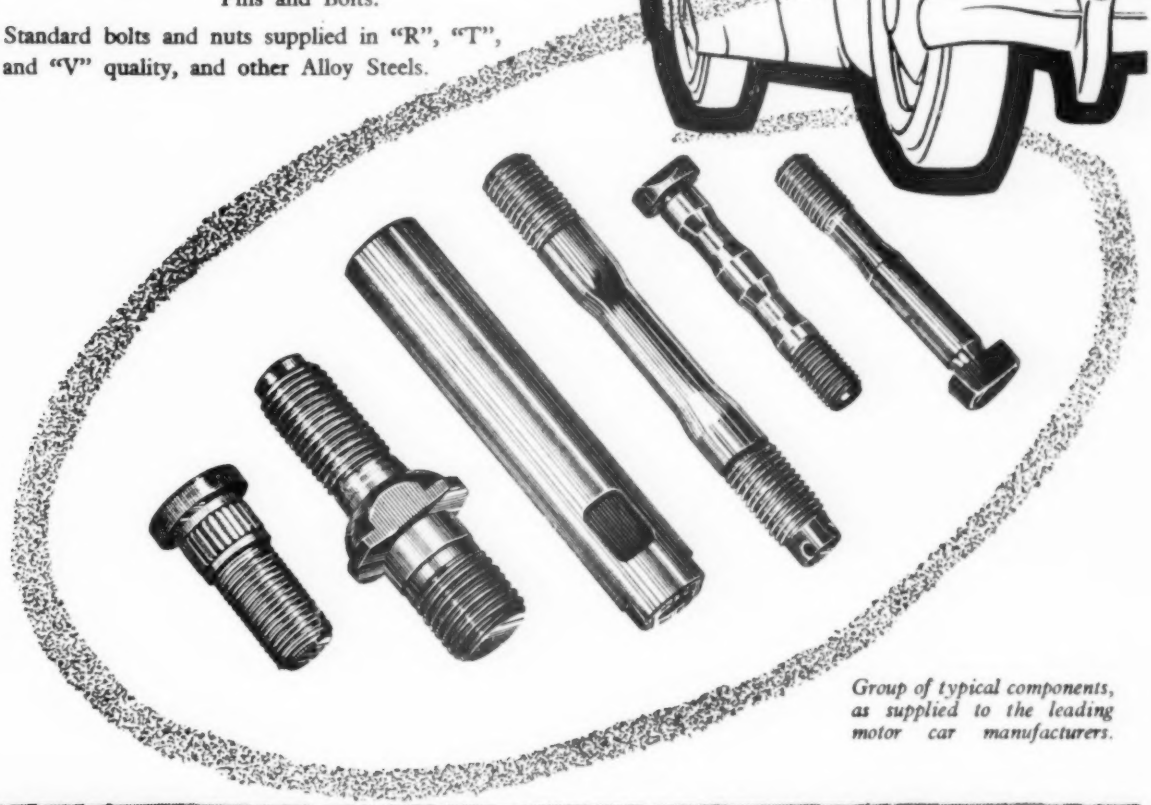

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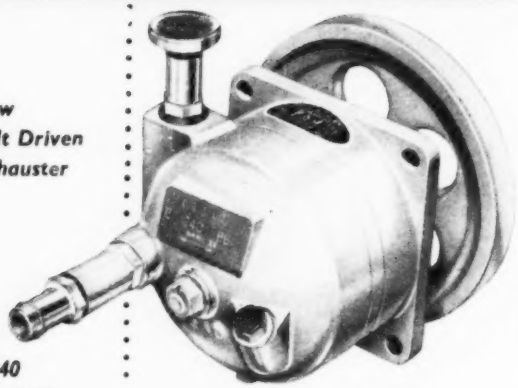

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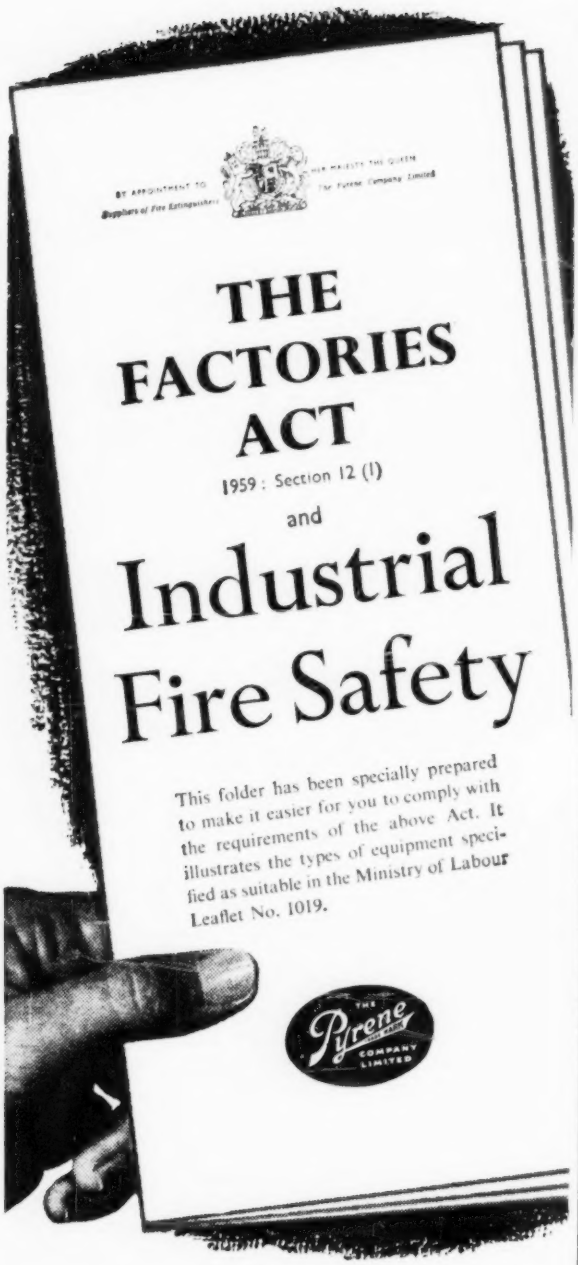
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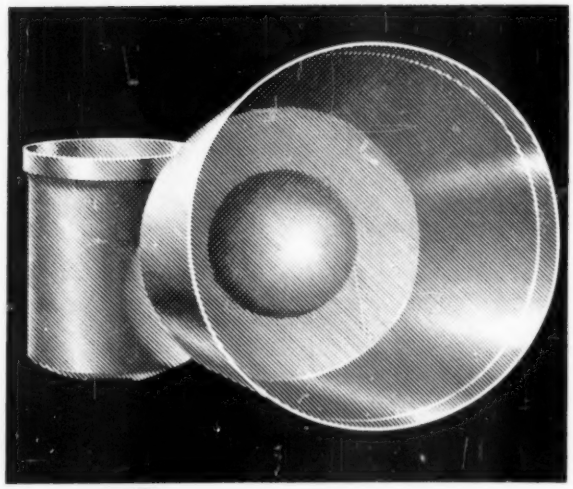

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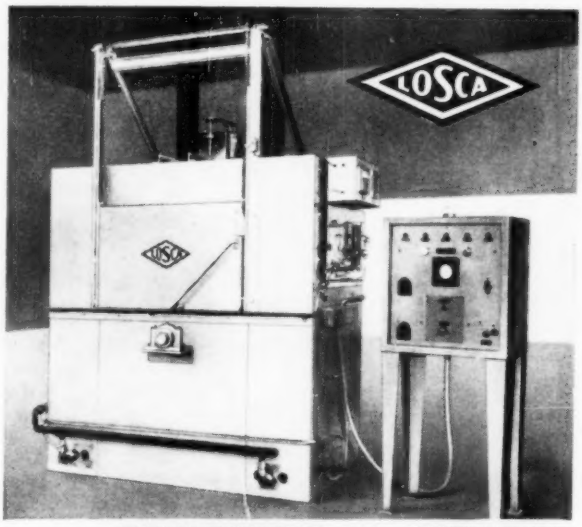

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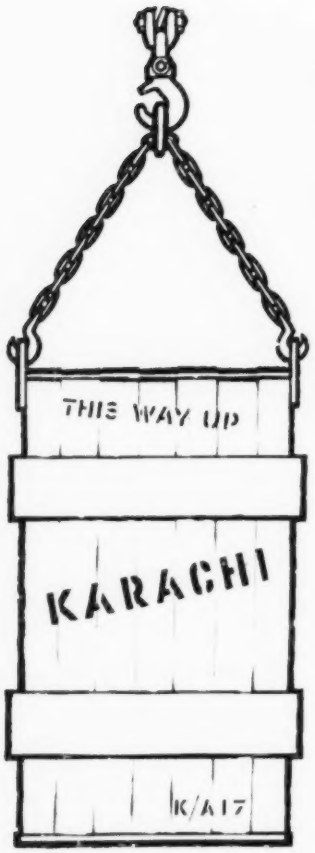

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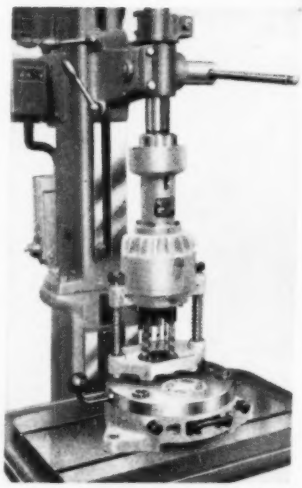

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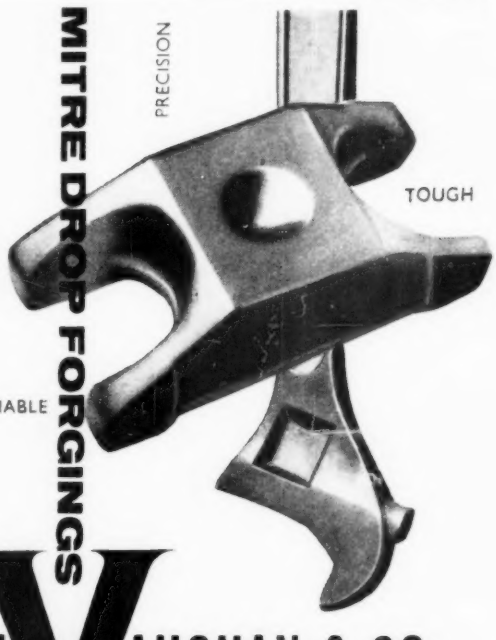

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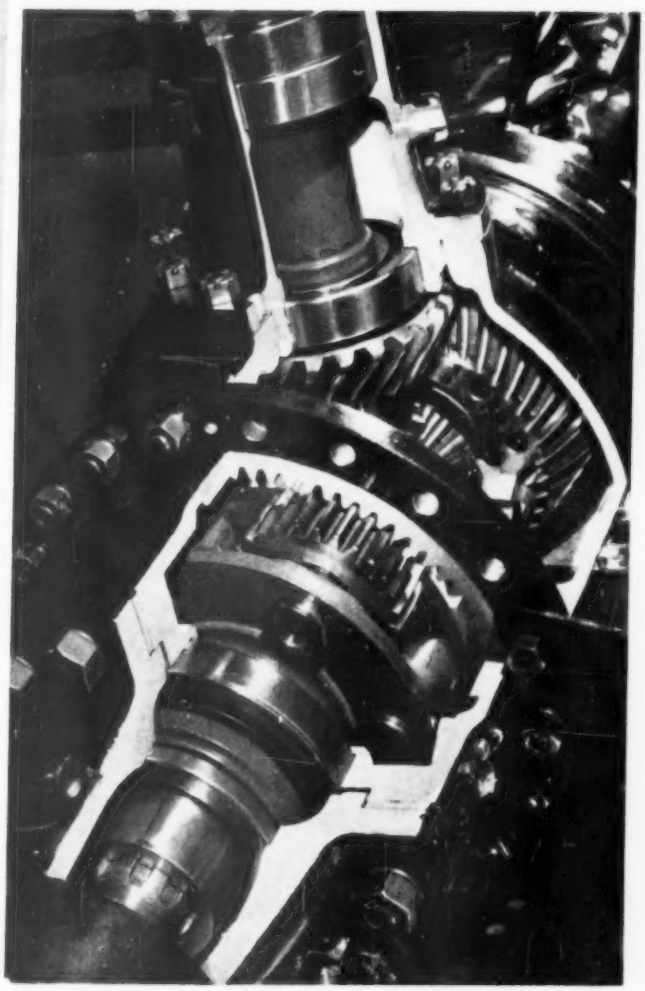

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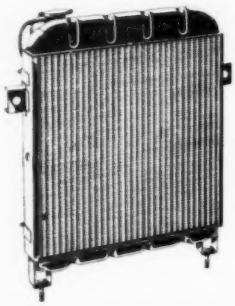

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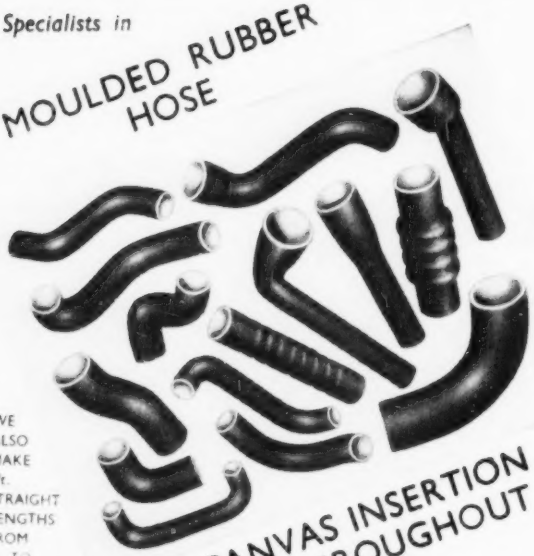

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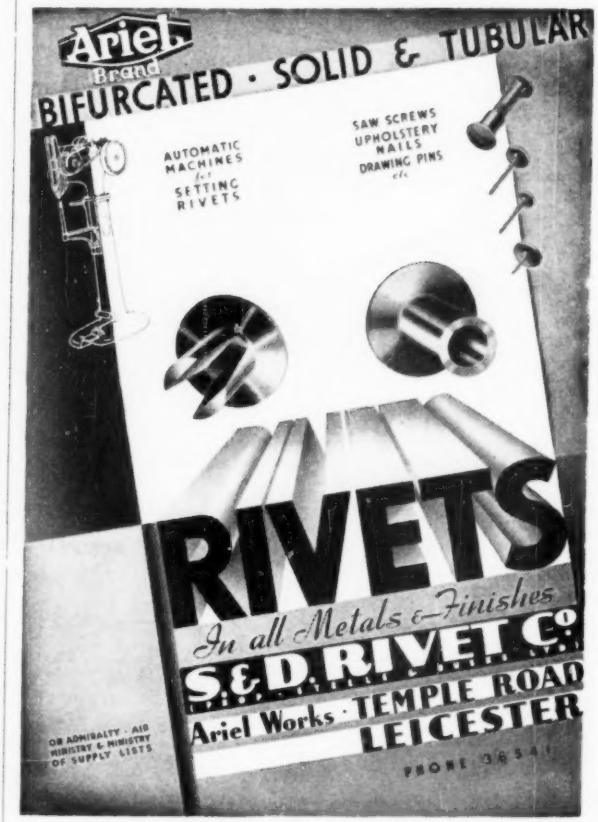

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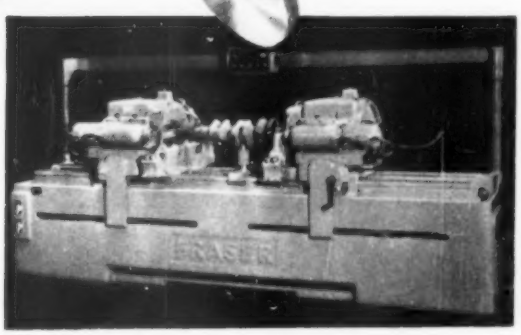

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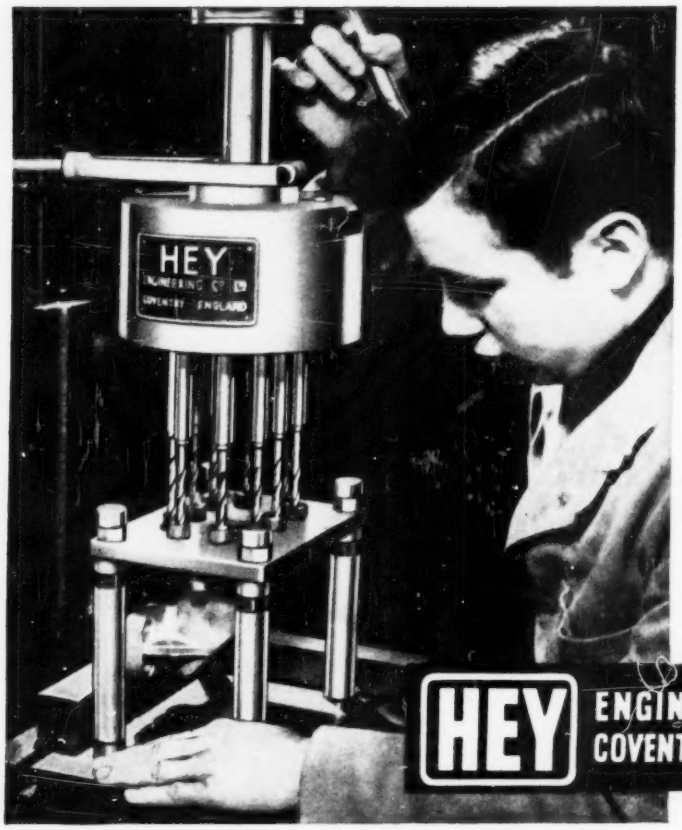

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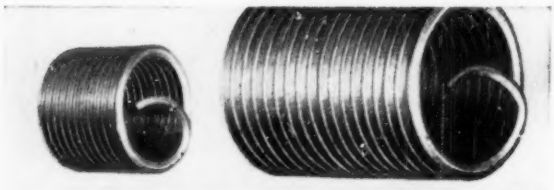

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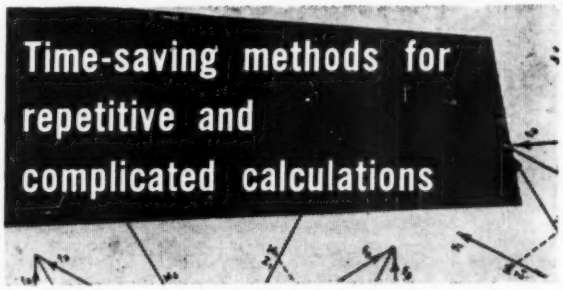

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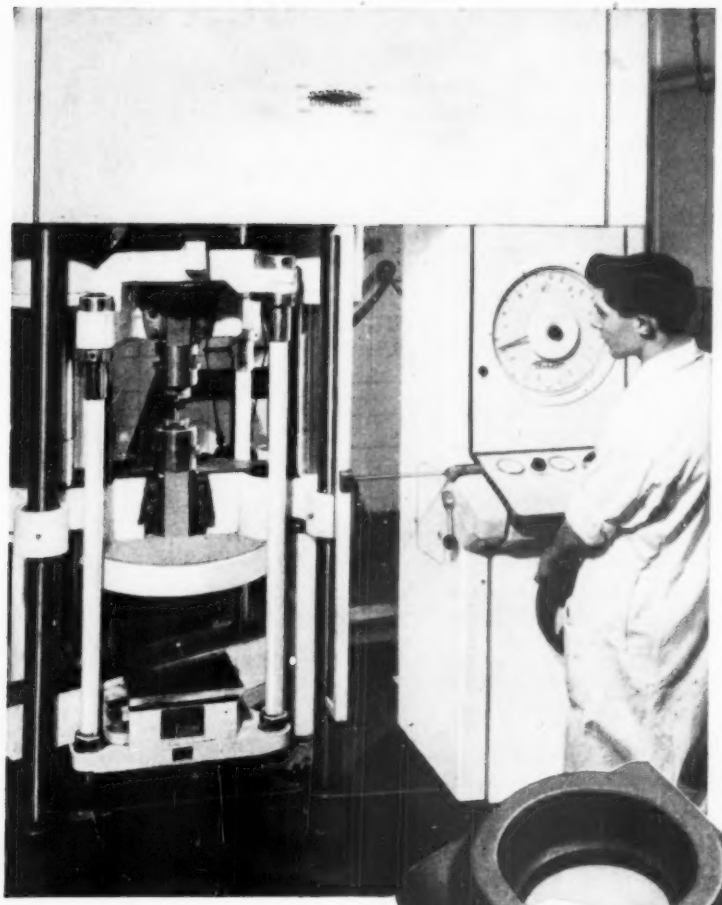

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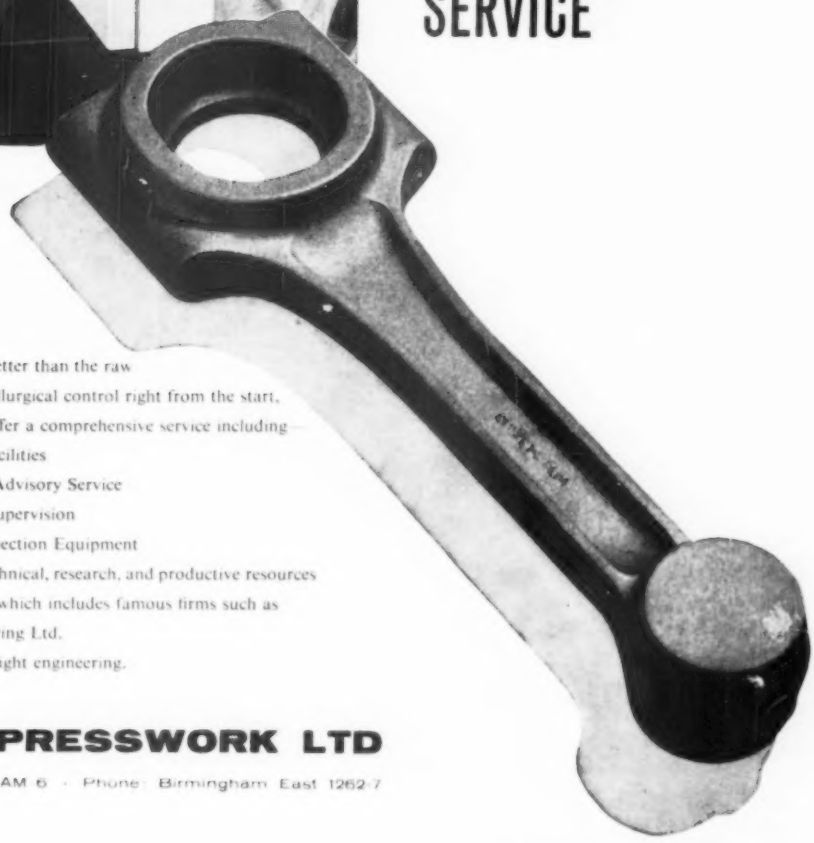

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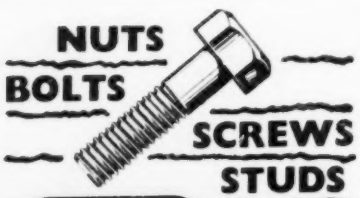

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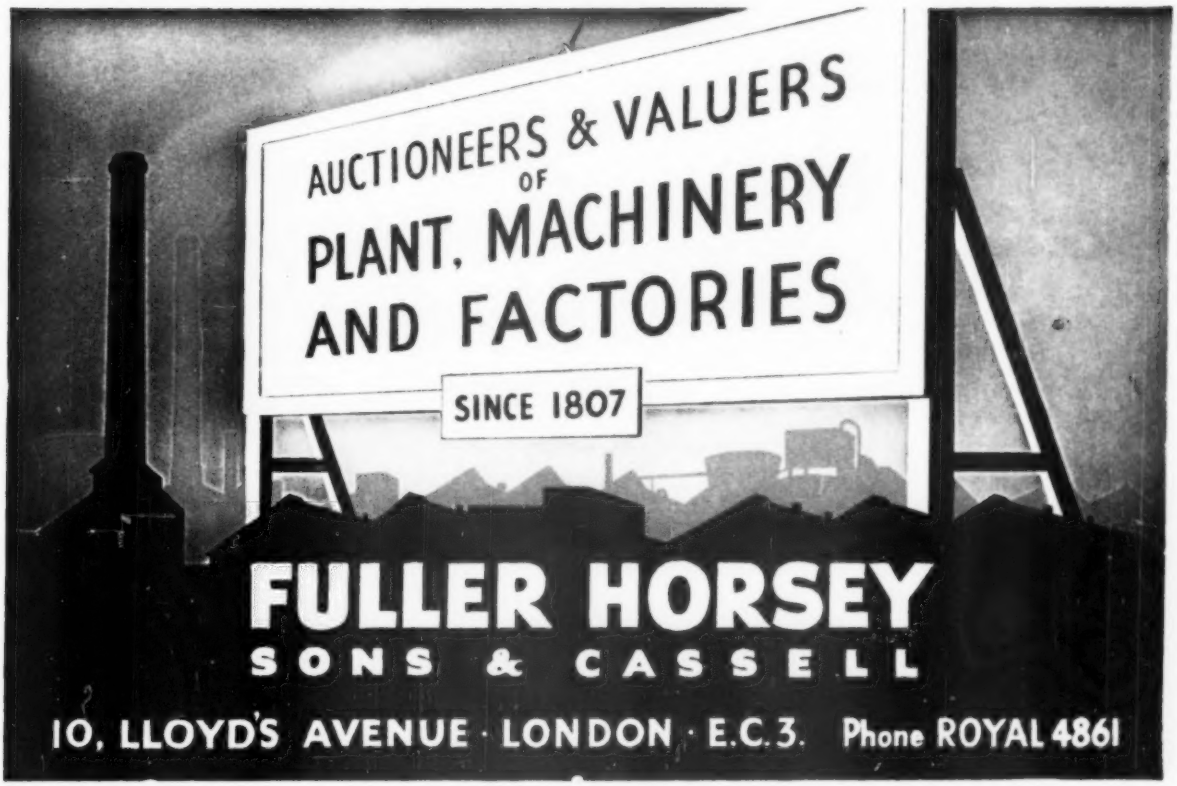

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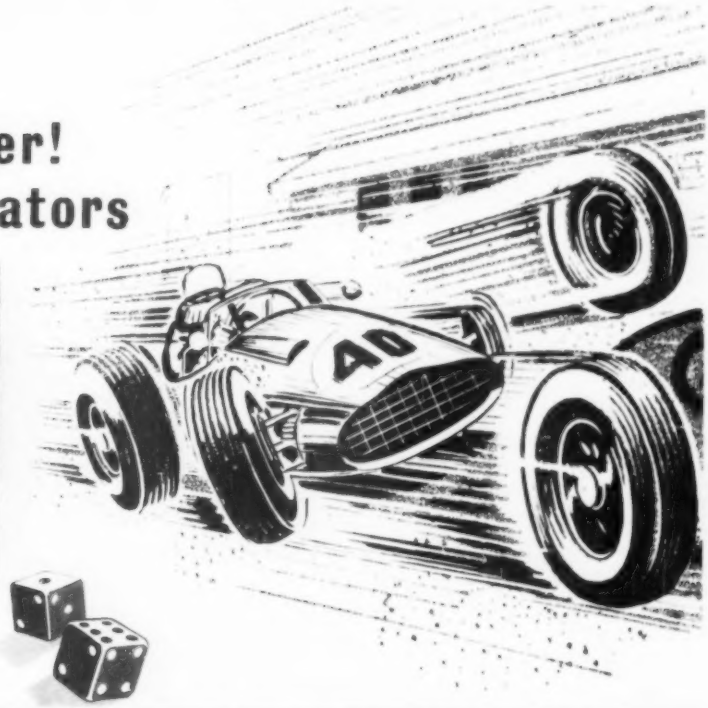

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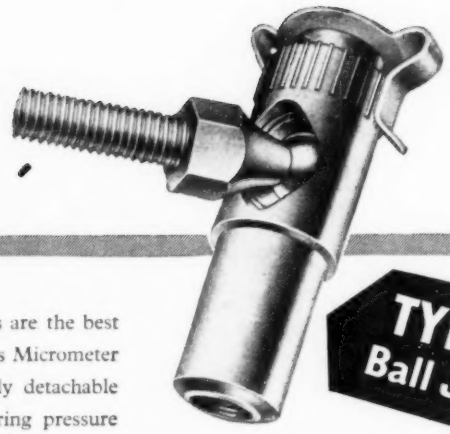

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INDEX TO ADVERTISEMENTS

	PAGE
Adamant Engineering Co. Ltd.	31
Aircraft-Marine Products (Gt. Britain) Ltd.	41
Air Industrial Developments Ltd.	93
Alcan (U.K.) Ltd.	45
Aluminium Bronze Co. Ltd.	108
Amal Ltd.	114
Archdale, James, & Co. Ltd.	23
Armstrong Whitworth Co. (Pneumatic Tools) Ltd.	29
Associated Electrical Industries Ltd.	61
Atlas Copco AB	Cover ii
Automotive Engineering Ltd.	103
Automotive Products Co. Ltd.	5
Avery, W. & T., Ltd.	95
Birlec Ltd.	43
Borg & Beck Co. Ltd.	8
Bound Brook Bearings Ltd.	12
B.R.D. Co. Ltd.	82
British Belting Co. Ltd.	101
British Oxygen Co. Ltd., The	39
British Piston Ring Co. Ltd., The	68
British Resin Products Ltd.	30
Broom & Wade Ltd.	58
Brown, David, Corporation (Sales) Ltd., The	11
Bull, John, Rubber Co. Ltd.	55
Bury Felt Mfg. Co. Ltd.	3
Bush, W. J., & Co. Ltd.	96
Cape Asbestos Co. Ltd., The	56
Castings Ltd.	83
Carradine & Miles Ltd.	102
Cashmore, John Ltd.	Cover iv
Churchill, Chas., & Co. Ltd.	33
C.A.V. Ltd.	42
CIBA (A.R.L.) Ltd.	48
Clancey, G., Ltd.	100
Clayton Dewandre Co. Ltd.	Cover iii
Clayton-Wright, Howard, Ltd.	14
Consolidated Pneumatic Tool Co. Ltd.	54
Coopers Mechanical Joints Ltd.	81
Co-ordinators Service (Engineering) Ltd.	106
Copper & Asbestos Washer Co. Ltd.	98
Cross Mfg. Co. (1938) Ltd.	110
Dartmouth Auto Castings Ltd.	70
Deloro Stellite Ltd.	90
Desoutter Bros. Ltd.	9
Dowty Seals Ltd.	72
Drummond-Asquith (Sales) Ltd.	63
Duralloys Ltd.	10
Du Pont Co. (United Kingdom) Ltd.	35
Edwards, F. J., Ltd.	112
Electrical Development Assen.	27
Electro-Chemical Eng. Co. Ltd.	88
Empire Rubber Co.	32
E.N.V. Engineering Co. Ltd.	59
Eyre Smelting Co. Ltd., The	106
Falk Stadelmann & Co. Ltd.	22
Farnborough Engineering Co. Ltd.	66
Feeny & Johnson Ltd.	100
Feltham, Walter H., & Sons Ltd.	112
Fenner, J. H., & Co. Ltd.	36
Ferodo Ltd.	44
Firth-Derihon Stampings Ltd., The	105
Firth, Thos., & John Brown Ltd.	28
Fletcher Miller	104
Forgings & Presswork Ltd.	111
Fry's Diecastings Ltd.	91
Fuller, Horsey, Sons & Cassell	113
Giddings & Lewis-Fraser Ltd.	109
Girling Ltd.	75
Habershon, J. J., & Sons Ltd.	94
Hallam, Sleigh & Cheston Ltd.	74
Hardy Spicer Ltd.	20
Heenan & Froude Ltd.	77
Herbert, Alfred, Ltd.	47
Hermetic Rubber Co. Ltd.	108
Hey Engineering Co. Ltd.	110
Hoffmann Manufacturing Co. Ltd., The	73
Holroyd, John, & Co. Ltd.	51
Holset Eng. Co. Ltd.	1
I.C.I. (Heat Treatment) Ltd.	15
I.C.I. (Marston Excelsior) Ltd.	106
Iliffe Books Ltd.	98, 110
Ilford Ltd.	46
Jackson, H., Ltd.	65
Kirkstall Forge Eng. Ltd.	26
Lanarkshire Bolt Ltd.	96
Lockheed Hydraulic Brake Co. Ltd.	6, 7
London & Scandinavian Metallurgical Co. Ltd.	102
Long Meadow Felt Co. Ltd.	40
Lysaght DeVilbiss Ltd.	17
Marsden, Samuel, & Son Ltd.	112
M.C.L. & Repetition Ltd.	112
Metalastik Ltd.	53
Midland Motor Cylinder Co. Ltd., The	69
Mills, Wm., Ltd.	86
Mond Nickel Co. Ltd.	97
National Coal Board	24, 25
Newall, A. P., & Co. Ltd.	99
Park Gate Iron & Steel Co. Ltd., The	52
Philidas Div. of Whitehouse Industries Ltd.	34
Pyrene Co. Ltd.	102
Qualcut Tools Ltd.	64
Ransome & Marles Bearing Co. Ltd.	37
Renold Chains Ltd.	79
S. & D. Rivet Co.	108
Salisbury Transmission Co. Ltd.	49
Salter, Geo., & Co. Ltd.	2
Sheffield Twist Drill & Steel Co. Ltd., The	13
Shell (Rotella) Ltd.	21
Shimwell & Co. Ltd.	100
Silentbloc Ltd.	19
Simms Motor Units Ltd.	60
Simmonds Aerocessories Ltd.	38, 87
Sintered Metal Components Ltd.	90
Skefko Ball Bearing Co. Ltd.	72
Slack & Parr Ltd.	104
Smethwick Drop Forgings Ltd.	67
Smith, C. & B., Ltd.	92
Speed Tools Co. Ltd.	94
Steel Co. of Wales Ltd., The	57
Sterling Metals Ltd.	76
Tecalemit Ltd.	4
Terry, Herbert, & Sons Ltd.	62
Thompson, John, Motor Pressings Ltd.	84
Timken Roller Bearing Co., The	Cover i
Toledo Woodhead Springs Ltd.	18
Tufnol Ltd.	89
Udal, J. P., Ltd.	113
Van Moppes, L. M., & Sons (Diamond Tools) Ltd.	50
Vaughan Associates Ltd.	85
Vaughan, A. J., & Co. (Mitre Works) Ltd.	104
Wellworthy Piston Rings Ltd.	107
Western Mfg. Co. Ltd.	78
Weston, Chas., & Co. Ltd.	16
Wild-Barfield Electric Furnaces Ltd.	80
Wiley, Jas., & Son Ltd.	92
Youngman, W. C., & Co. Ltd.	112

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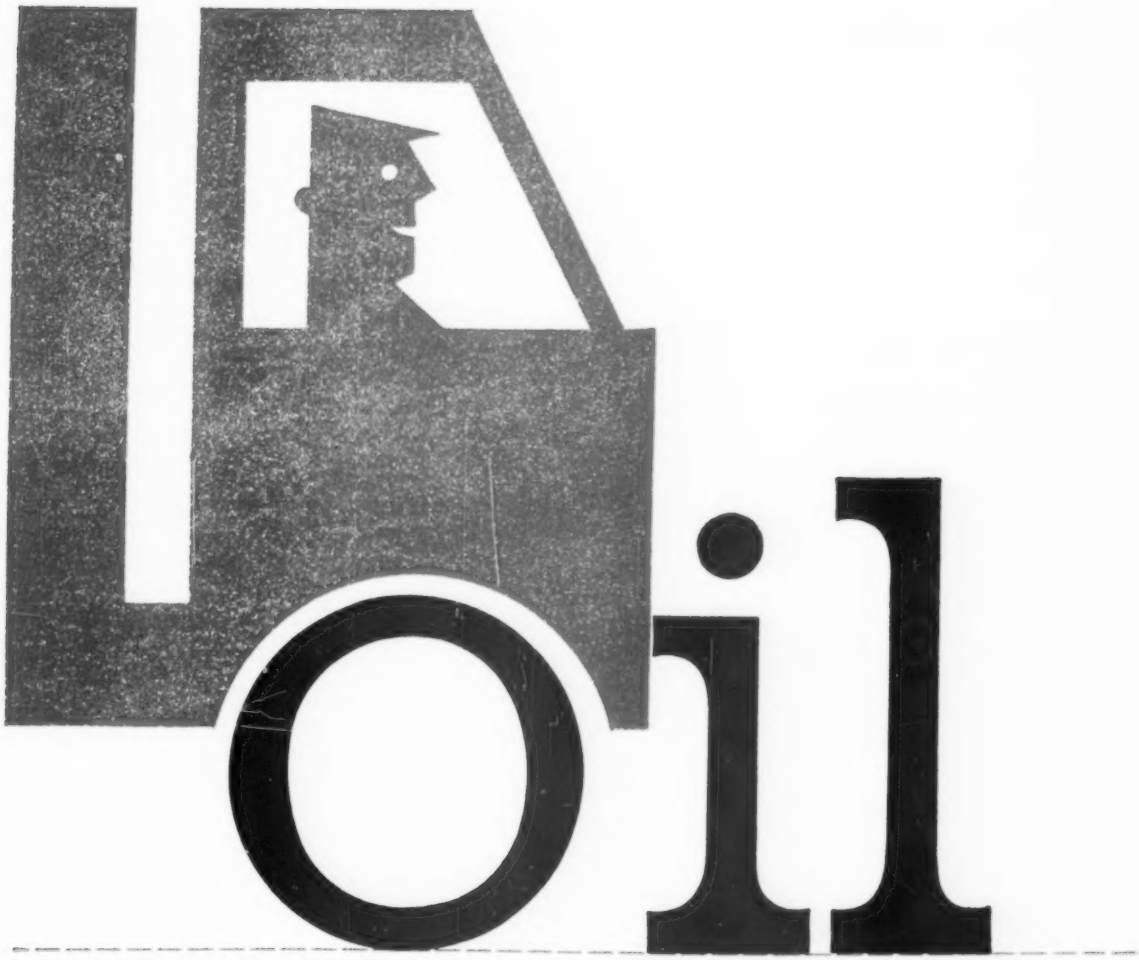

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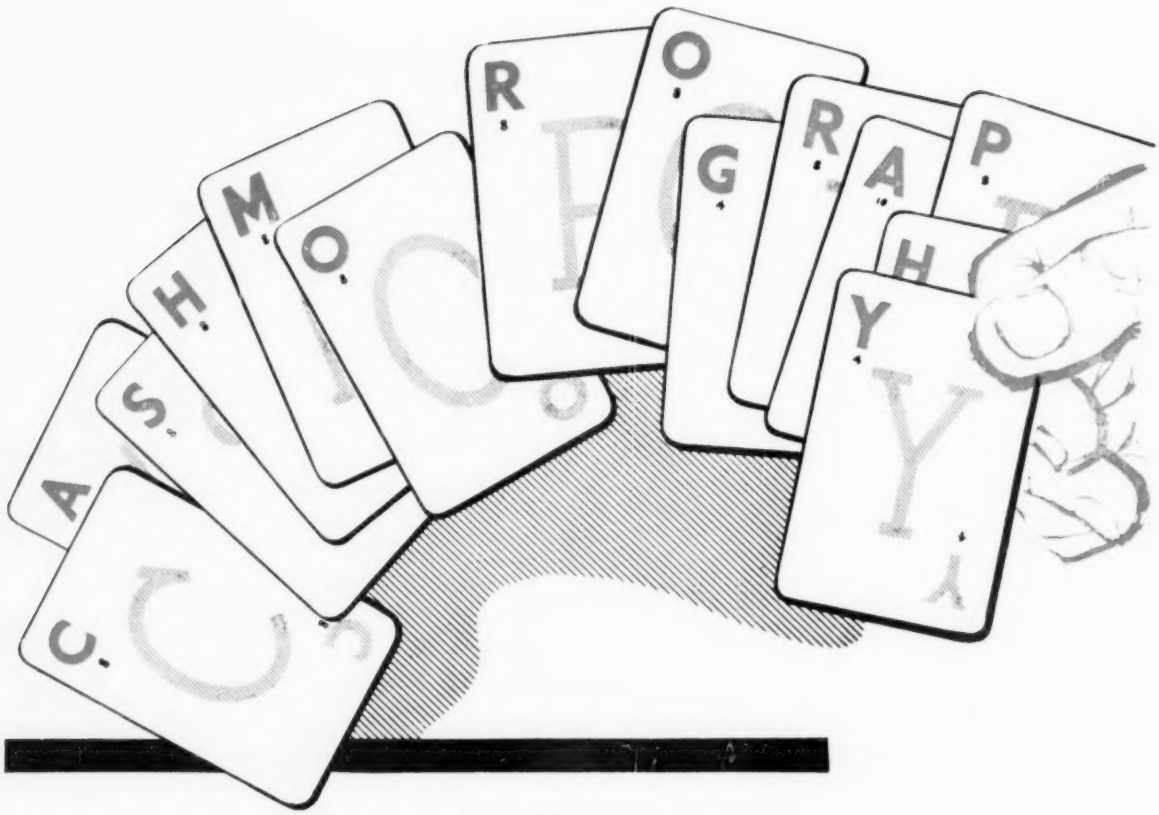

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